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FOOD FOR THE FUTURE

HEARING

BEFORE THE

SELECT COMMITTEE ON HUNGER
HOUSE OF REPRESENTATIVES

ONE HUNDRED FIRST CONGRESS

SECOND SESSION

HEARING HELD IN WASHINGTON, DC, OCTOBER 16, 1990

Serial No. 101-25

Printed for the use of the Select Committee on Hunger

U.S. GOVERNMENT PRINTING OFFICE

37-950 ⇆ WASHINGTON : 1991

For sale by the Superintendent of Documents, Congressional Sales Office
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FOOD FOR THE FUTURE

TUESDAY, OCTOBER 16, 1990

HOUSE OF REPRESENTATIVES,
SELECT COMMITTEE ON HUNGER,
Washington, DC.

The committee met, pursuant to call, at 2:05 p.m., in room 2359A, Rayburn House Office Building, Hon. Tony P. Hall [chairman of the committee] presiding.

Members present: Representatives Penny, Bustamante, Long, Emerson, Gilman, and Smith of Oregon.

OPENING STATEMENT OF HON. JILL L. LONG, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF INDIANA

Ms. LONG [presiding.] The meeting will come to order.

Chairman Hall is at a Rules Committee meeting and has a couple of critical votes coming up, so he's going to be a little late. And without objection, I will read his opening statement.

PREPARED STATEMENT OF HON. TONY P. HALL, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF OHIO

We are here today to talk about a subject that is the real essence of the Hunger Committee's work—the challenge of how we are going to produce enough food to feed the growing world population in the future.

As a committee we spend a lot of time talking about wars and famines, food relief and food stamps, but it is almost all too easy to overlook what is the most important question of all: How is the world going to be able to continue to grow more food to feed the world and save the environment?

Unfortunately, the picture right now is not good. Between 1959 and 1984, the world grain harvest expanded about 3 percent per year, while output rose only 0.2 percent in the first half of this decade and has continued to slow down; only last year there was an 18 million ton shortfall in the world grain harvest.

In 1988, we experienced a tremendous drought in this country which damaged the U.S. grain crop to the point that it fell below consumption for the first time in history. But no American went hungry because of it. Why? Partly because the United States is in the fortunate position of having stocks that buffered the shock. In the Sudan, the effect of such a shock would literally cripple the country—a food price rise that is merely annoying to the world's affluent can mean life or death to the poor in the developing world.

So, sadly, we have a new problem to add to the growing list of world problems, and that's food scarcity. The world enters the nineties not only with a low level of grain in reserve, but with little confidence that stocks can be rebuilt quickly; the consequences of more poor harvests when we already have low stocks, as we now have, could be disastrous worldwide.

The problem of sufficient food production is emerging as the most immediate consequence of global environmental degradation—it is already affecting the welfare of hundreds of millions of people, particularly in the developing world where the share of hungry and malnourished people has increased.

What does this mean?

It means that as supplies tighten in more and more countries, prices will rise, and people—particularly the poor in developing countries—will go hungry. Perhaps the

most tragic consequence of the deteriorating food situation in Africa and Latin America is the alarming increase in nutrition-related child mortality.

It is clear from the evidence and research at hand that the world needs to continue to strengthen agriculture in every way possible. A massive international effort is needed to protect soil, conserve water and restore the productivity of degraded land.

So; today, World Food Day, it is completely appropriate that the Select Committee on Hunger holds a hearing on Food for the Future, on feeding the world in the next century. We are here to gain a better understanding of what the nature of the problem is and what our panel of experts in the field of food policy, sustainable agriculture, and biotechnology are talking about in the way of solutions.

I look forward to hearing your reports.

Ms. LONG. We just got called to a vote but I think we'll go ahead and begin, and possibly another member will come in and be able to take the chair; and if not, we will have to recess temporarily.

The first panel—it's a pleasure to introduce the members of this panel—John Mellor is the director of the International Food Policy Research Institute, and will be summarizing his paper "Ending Hunger: An Implementable Program for Self-Reliant Growth," which has been submitted for the record.

Thurman Grove, a senior research associate at Cornell University, will be talking about the importance of preserving our natural resources for sustainable agriculture.

Mr. Grove is currently working in the Bureau of Science and Technology at the Agency for International Development, but will be speaking in his personal professional capacity, not as a representative of A.I.D.

Mr. Mellor, please begin.

STATEMENT OF JOHN W. MELLOR, DIRECTOR, INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

Mr. MELLOR. Thank you very much, Ms. Chairperson. I'm grateful for the opportunity to be here. Laura Henderson and I have prepared a statement which we would like to put into the record. You gave the title of it—I would like to emphasize the implementable and the self-reliant aspects that are in that title.

I would like to try and draw a bit of the essence out of this paper for a very brief oral statement. Of course, what we're talking about today has been something on our minds for a long time; my own early recollections go back to the enunciation of the four freedoms—but that was not the beginning of talking about ending hunger in the world; it was just a milestone along the way.

I've just come from a very moving ceremony over in the Old Executive Office Building—the Presidential End Hunger Awards were given. I'm very proud that a number of years ago I received one of those. But I am touched every year, not by the fact that someone who thinks about these issues, like myself, gets one of those awards, but by the tremendous hard-working grass roots effort which is represented by a number of the recipients—people that are out there on the firing line.

I would like to bring a rather optimistic perspective to this idea of ending hunger in the world. And one might wonder why do I think we have better prospects now of ending hunger in a decade, or two decades, or at most, three decades as compared to the situation three or four decades ago, when I would not have taken such

an optimistic view. I had an optimistic view then also, but five, six decades in the future. I think we've been marching down that path.

I think there are two things that I should draw attention to. First of all—and I will give some evidence on that in a moment—we've had some very striking evidence, demonstration, of tremendous reductions on a very large scale of the kind of poverty which is associated with hunger in the world. And we want to keep in mind that hunger and poverty go hand in hand, and the hungry poor are the very poorest people in the world. When you get yourself up into what I would call ordinary poverty, which is the kind that I lived in in the 1930's on a hill farm in Vermont, you're not particularly hungry. You may not be happy about your diet—as I wasn't in those days—but you're not hungry. We're talking about the poorest in the world.

There has been a radical reduction in a number of countries, which I will refer to, and some of them are a bit surprising.

The other thing that's changed over the last few decades, we know a great deal more about what to do about getting the kinds of development and growth which can eliminate hunger in the world.

I want to, first of all, trot out a few numbers, and each with a purpose. First of all, the problem of hunger in the world, although I think it's something we can succeed in reducing and getting rid of, is now massive. And the number which I think is most appropriate is 1 billion. There are roughly 1 billion people in the world who are so poor that they are getting inadequate calories for an active life.

Academics like me argue about all sorts of arcane points about whether the body adjusts to a reduction in calories or not. Frankly, those are nice discussions for well-fed people to have, but we're talking about people whose poverty is so great that the number of calories they're getting are such that their bodies cannot adjust to that except by being sedentary and not being able to work actively. And any way you slice it, there are about 1 billion such people.

Why is it important to emphasize that number? The reason is that if you're dealing with such a massive amount of poverty in the world, you cannot reasonably think in the real world that we live in of dealing with that through redistribution. You can't just redistribute a bit here and there.

Yes, there are enough calories in the world for everybody to have enough. But, are we going to eliminate livestock from our diets in Western Europe and the United States in order to provide something like six times as much food aid as we're providing now to deal with the problem of redistribution? I doubt it. I don't see much evidence of that.

But we're dealing with too big a problem for redistribution, and I will come back to obviously the other side of that coin—the growth coin—in a moment.

Second, those 1 billion people are heavily concentrated in the poorer countries of the world—the ones that are short of resources. Half of them are in South Asia, which means India, Pakistan, Bangladesh, et cetera. About 20 percent of them are in sub-Saharan Africa. There are 2½ times as many of these hungry poor in South Asia as there are in sub-Saharan Africa. Incidentally, the numbers are on the way to being radically reduced in South Asia, so that

shortly somewhere between the year 2000 and the year 2010, the way things are going now, the numbers in South Asia will be down substantially; the numbers in sub-Saharan Africa will be up, and we will have more hungry poor in sub-Saharan Africa at that time than there will be in South Asia at that time. So we need to look very much at sub-Saharan Africa. About 10 percent of those people are in China. That takes care of 80 percent of them.

They are mostly rural. In sub-Saharan Africa, 90 percent are in rural areas. In Asia, 80 percent. In Latin America, 60 percent. So that we're talking about a massive problem, 1 billion people, in poor countries, and in the rural areas of those poor countries.

The last number I want to trot out—of those people so poor that they are hungry, about one-half of them are on agro-ecological circumstances—soils and rainfall regimes, irrigation regimes—which lend themselves to the high yielding, high productivity crop agriculture, which has eliminated so much hunger already in similar kinds of areas. But there are large areas where we have not done the job in moving those kinds of agriculture. And, again, I will come back to that in a moment.

Ms. LONG. Mr. Mellor, I think I'm going to have to run and vote. So if we could recess very shortly and as soon as the vote is completed, then we will resume.

Mr. MELLOR. OK. I'll know exactly where I was in the middle of that sentence.

Ms. LONG. Mark it. I've got it right here, if you need it.

Mr. MELLOR. No, that's fine, thank you.

[Recess.]

Mr. HALL [presiding.] I'm sorry that I'm late. This is the first time this year I've ever been late to a Hunger Committee meeting. It's an unusual day—and I appreciate having you here.

I understand you're in the middle of your testimony, right, as I remember.

My statement has already been made, apparently, by Congresswoman Long, so please proceed.

Mr. MELLOR. OK, thank you. I won't go back over. You have staff I would be happy to have that will do the necessary, as we say.

What I essentially tried to do was to indicate some reasons why I'm hopeful about the future in getting rid of hunger in the world, indicating that it is a massive problem, and indicating something of where that hunger is in the poor countries and the rural areas; and a great deal of it, half of it, in areas in which we know how to increase agricultural production very substantially. The poor are well over half in areas with a lot of potential and areas we should work on.

I was just about to move in making some comments about what is hopeful about the situation in eliminating hunger in the world at the present time. And I want to go back to my earlier comment that hunger is essentially a matter of poverty and poverty at very low levels. I want to talk with respect to poor countries where the processes of economic growth have brought about a halving of the number of people under the absolute poverty line which is associated with hunger.

And I want to start with a particularly improbable example—Brazil. We generally have a view, and correctly so, that the distri-

bution of income in Brazil is rather unfortunate—a very heavy concentration with high income people. That, of course, is correct.

We also have a view that in the 15 years of the Brazilian miracle—a very rapid growth—we have the view that the distribution of income worsens somewhat during that period. That may be correct, although it's highly debatable.

What is not debatable is that during the 15-year Brazilian miracle, the numbers of people falling under the absolute poverty line, which is associated with hunger, more than dropped in half. So here we have a country which we do not think of as a success story in dealing with equity issues in which hunger was cut in half when they were able to sustain their high growth rate—and, of course, we all know a number of the reasons why their growth rate came to a halt.

A much more probable example is Thailand, which has managed to maintain rapid growth more or less forever—going back to the latter part of the 1950's. They've been sustaining a 10-percent-growth-rate in GNP over the last several years, and they've been above 6 or 7 percent over the last 20 or 30 years.

In each 15-year period over the last 40 years, Thailand has again reduced the proportion of its population falling under the absolute poverty line; in other words, the hungry poor have reduced by one-half in each successive period. That's an incredible record.

Now I want to go back to an improbable one again—India. There are five states in India which have had high rates of growth in their agricultural sectors over the last 20 years. Those five states were, for those of you who follow these things closely, are the Punjab, Haryana, Andhra Pradesh, Gujarat, and Kerala.

Those five states, again in a 20-year period, more than reduced by one-half the number of people in their rural sectors in poverty sufficient to be hungry. In other words, they cut hunger in half, to put it very simply. Four of those five states are the four states which had the highest growth rates in their agricultural sectors during that 20-year period. And it is that rapid growth in agriculture and the things that went along with it—the stimulus which it had to the rural nonagricultural sector which brought about the increases in food production and the increases in incomes in the hands of the poor which allowed this radical elimination of poverty in those states.

Now, there are a lot of other states in India which had an abysmal record in agricultural production and in growth overall, and poverty increased in those states; and the balance of the two has been little decrease in poverty in India. But I think it's very instructive to focus on those states where there was a very successful record in agriculture.

One of the five, incidentally, did fairly poorly in agriculture—that's the state of Kerala. That's the state which has unusually high educational levels. And this may sound facetious, but what they did in Kerala was not learn how to produce better at home, but they learned how to educate their people so they could leave—and they've had a long history of leaving that state.

They left for other parts of India; didn't prosper greatly as a result. When the opportunities in the Gulf opened up, they went in

very large numbers to the Gulf; remitted large sums of money back, and that had a very favorable effect in reducing poverty.

I could have trotted out similar numbers for Indonesia where the proportion of the rural population in absolute poverty has also dropped in half. I could have done the same thing for Malaysia. We have a number of very exciting examples.

What do these countries have in common that we can learn from? Here it's rather prosaic. No. 1, they all did a first class job on agricultural technology. They developed agricultural research systems to a significant part with the help of the United States and the U.S. title 12, and related farm assistance programs, in building a technological capacity to produce more food at home in an efficient way. And they built the ancillary institutions of extension, education, fertilizer distribution systems, cooperatives, and so on, to go along with that.

Second, they integrated the mass of their rural people into the total development process. They did that by building all-weather rural roads on a major scale. You can't lift people out of hunger when they're isolated. When they're isolated by nonoperable roads and so on. When they're isolated, if they have a bad crop year, you can't get the food in there to help them. And when they have a good crop year, you can't get it out. And in any case, they don't have a good crop year very often because you can't get new technology in, you can't get people in who are interested in selling fertilizer, you can't get new ideas in, so forth, and so on.

So these countries built rural roads on a massive scale. Something that we did, of course, at a much earlier stage in our development.

Third, they educated their rural people. They got widespread rural education; not just at the primary school level but pushing people on up into secondary school. And I might add, where educational systems are very ineffective and inefficient, you don't really learn much in primary school. You pick up a few tools, you learn a little bit about how to read, how to calculate, and so on, but you don't learn how to apply it. It's the secondary school education that put all those things to work.

Fourth, they had a good macro policy environment. They had favorable price policies, favorable exchange rates, and so forth, and so on.

I put that in as fourth because nowadays we tend to put that first far too often. It doesn't do much good to have macro policies favorable to growth and agriculture and eliminating poverty if there are no roads, no schools, and no technology. It's the macro policy which makes a favorable environment for those things to work.

What can the United States do in this context? And the context I'm indicating is one of a massive problem. It has to be dealt with, with growth and, of course, supplemented by some redistributive efforts—the type that UNICEF talks about, the World Health Organization, and so on, but underlying it effective growth in rural areas with agriculture as the core of it.

What can the United States do in this context?

I want to pick up on the two prongs of what A.I.D. is putting forth in its strategy at the present time and look with favor on those in this context.

The first one is democratization. Yes, if you're going to have the kinds of growth which reduce poverty and eliminate hunger in the world, of course we have to talk about broad participation in democratic processes.

Please remember that means developing viable local government in developing countries. They've been too urban run, too much by big city people. If you're going to really talk about democratization, you're really going to talk about building rural roads and rural schools, rural people have to be involved in the political process. And let's get down to that micro level when we talk about democratization, and it is happening in much of the world.

Second, we should talk, and do talk, about privatization. If developing countries are going to create jobs in their rural areas to lift people out of hunger, yes, agricultural growth has to be part of that, providing the spendable income for farmers that stimulate activities in the rest of the rural sector. And those activities are going to be private sector activities run by small entrepreneurs, small businessmen, who make employment when they develop their firms and their industries, and so on, as distinct from the large-scale steel mills, the multinationals, and so on.

So, yes, there's a tremendous place for the private sector. It is going to be the core of providing the jobs to move hunger out of the rural areas of these countries. And it's a private sector, which, like our small-scale private sector, needs some public support in building roads for them to transport on and having communication systems, and having credit programs, and so on. So we have to see a private sector supported by the kinds of public sector activities that our small businessmen expect in this country.

Third, in direct action, A.I.D. needs to get back to the business of helping developing countries develop their technological capabilities in agriculture; get back to a vigorous title 12 program; back to a vigorous land grant college effort in building institutions of higher education that can develop research to do proper kinds of all-weather roads for their circumstances. For example, that's what a good agriculture engineering department should be doing in a developing country.

What are we doing to help develop that? What are we doing, for example, to help develop the agriculture engineering department to do low-cost water systems and low-cost roads, which are appropriate in rural areas of low-income countries.

What are we doing to see to it that there is development of the right technology for efficient use of fertilizer in these countries—agronomy, and soil science departments, and so on?

A.I.D. needs to get back into that effort and to get agriculture and agricultural technology back up front within the broad emphasis on democratization and privatization.

Finally, the United States and A.I.D. and the Treasury Department need to urge on the international financial institutions to, of course, keep pushing on the right macro environment. But now that they're getting it, to get back into the projects of seeing to it that rural roads get built, see that rural education gets pursued;

and seeing to it that we get technologies which can provide the basis of growth, which we've seen in the successful states in India, which we've seen in Thailand, which we saw in spades, of course, in Taiwan—they've gone so far we don't notice it anymore—that we've seen in Indonesia, and in a number of other cases.

Thank you very much.

Mr. HALL. Thank you, Mr. Mellor.

[The prepared statement of Mr. Mellor appears at the conclusion of the hearing, see p. 39.]

Mr. HALL. Mr. Grove.

STATEMENT OF THURMAN GROVE, SENIOR RESEARCH ASSOCIATE, CORNELL UNIVERSITY

Mr. GROVE. Thank you, Mr. Chairman. I appreciate this opportunity to share with you my views on the role of sustainable agriculture in meeting world food needs.

Between 1950 and 1984, the farmers of the world raised world grain production nearly threefold, an increase that's dwarfed all previous gains in agriculture.

Since then, unfortunately, additional gains have been very limited.

Growth in world food supply is impeded by environmental degradation, a worldwide scarcity of cropland and water for irrigation and a diminishing response to the use of additional fertilizers.

World food supplies depend heavily upon the availability of productive land. Ninety-eight percent of all human food supply comes from land.

Productive lands are threatened by soil erosion, loss of soil fertility and rapid runoff of water that results from land degradation. Each year about 7 million hectares of agricultural lands are abandoned because of this degradation.

In the United States average rates of soil erosion are 18 times the rates of soil formation. One-half of the rich and fertile soils of the State of Iowa have disappeared during the last 100 years. In Asia, Africa, and South America, soil erosion rates average 30 to 40 times the rates of soil formation.

In the tropics, desertification and deforestation resulting from the collective actions of millions of impoverished and desperate rural people degrade an additional 8 to 12 million hectares of land. Loss of vegetation exhausts the capacity for replenishment of soil fertility and increases runoff of water that is essential for crop growth.

While numerous and diverse technologies are currently available for reducing soil erosion, environmental compatible alternatives that maintain soil productivity for the rural poor of developing countries are not yet readily available.

Approximately one-third of world food is produced under irrigation. Yet irrigated agricultural lands are threatened by inefficiencies in water management and degradation of soils.

Agriculture accounts for 70 percent of human use of water worldwide and 85 percent in the United States, but efficiency of use is very low. Only 40 percent of irrigation water ends up benefiting crops. Increasing demands on surface waters and subterranean

aquifers will likely lead to water shortages if we don't improve these efficiencies.

Nearly half of all irrigated lands have been rendered unproductive through soil degradation, degradation of irrigated soils by lack of adequate drainage lowers production on 30 percent of all lands currently irrigated.

Technologies for improvement of water use efficiency and for preventing soil degradation are available, but we have little knowledge of how to justify them economically in the short-term.

Each year agriculture uses nearly 2.5 million tons of pesticides. Despite this heavy use about 35 percent of all crops are lost to pests.

In the United States the share of crops lost to pests has doubled since 1945 despite a tenfold increase in the use of pesticides.

Worldwide health effects of pesticides include 1 million pesticide poisonings annually, 20,000 of which result in death. The incidence of pesticide poisonings is highest in developing countries where ill health impinges directly upon human productivity in the agricultural sector.

In addition to their effects on pests, pesticides destroy beneficial organisms and wildlife which often leads to increasing reliance on pesticides.

And most importantly, I think, resistance to pesticides among pests is increasingly common. Pesticide manufacturers and plant breeders are hard pressed to keep ahead of the evolution of pesticide resistance by plant pests.

Recent studies by Professor David Pimentel at Cornell University have shown that it would be possible to reduce pesticide use in the United States by one-half, without changing crop yields, through use of currently available technologies, such as integrated pest management and biological control. This reduction would significantly reduce the negative effects of pesticide use.

The rapidly emerging field of sustainable agriculture provides us with alternatives to address environmental degradation of agricultural systems and to preserve their capacities to provide for food needs of current and future generations.

The concept of sustainable agriculture requires that we explicitly consider future generations in our current decisions; that we adopt policies and practices that will preserve options for future generations; and that we make preservation of the renewable natural resource base upon which all agricultural depends, an explicit goal.

We don't yet know how to do sustainable agriculture. It is still in the research and development phase. Professor Vernon Ruttan at the University of Minnesota warns us not to behave as though it is in the policy phase or we will inevitably make mistakes and discredit this new approach.

However, we are learning very rapidly and we can begin to implement innovations that are promising. Mostly what we are learning is that there are numerous biological alternatives that we can substitute for practices that degrade the environment.

Renewable natural resources such as soil are largely renewed by organisms—living creatures. We need to preserve biological diversity within agricultural systems to maintain this renewal capacity.

For example, soil organic matter, which provides nutrients and stabilizes soil structure, results from the death of plants and animals that grow in and on the soil. Nutrients are released from soil organic matter and made available for plant use through decomposition by a diverse suite of organisms that live in the soil.

Conventional tillage of soils and application of agrichemicals reduces the biological diversity of soils and thus creates conditions that demand application of even greater amounts of agrichemicals. Crop rotations, living mulches and reduced tillage provide alternatives that maintain the biodiversity of the soil and lead to maintenance of its renewal capacity.

Soil erosion is best controlled by maintaining vegetation on the soil surface. Minimum tillage, cover crops, crop rotations and living mulches are effective at reducing soil erosion and recycling soil nutrients. Researchers at Rutgers have, through use of living mulches, prevented soil erosion and maintained yields of corn and soybeans without use of herbicides or nitrogen fertilizers.

Biological control of pests offers alternatives to use of chemical pesticides. In the United States, insecticide application is greatest on corn, principally to control corn borer where corn is grown continuously. When corn is grown in rotation with other crops, the life cycle of the corn borer is interrupted and no pesticides are required. Studies show that income from a corn-soybean rotation is typically higher than when either crop is grown alone.

Recent studies in the United States at Ohio State and other universities and in Europe show that management for plant diversity in borders of fields and hedgerows results in increased diversity of predators and smaller populations of plant pests. Fewer pesticides are thus required, costs of inputs are reduced and biodiversity is maintained. A pleasant side benefit of this practice is an increase in the numbers and diversity of birds and small mammals.

While sustainable agriculture is still an hypothesis, its preliminary results are encouraging. A recent report of the National Academy of Sciences shows that farmers are successfully adopting sustainable agriculture techniques.

Sustainable agriculture has potential to reverse degradation of agricultural lands and to maintain their capacities for food production for current and future generations.

While the need for alternatives is pressing, we must also keep in mind that it has taken nearly 50 years of research and development to develop the current state-of-the-art for conventional agriculture. It will take time to perform the research and development that will provide necessary technologies and lead to the appropriate policies that are required for sustainable agricultural development.

But more than that I think we need a will and commitment not only to support the research and development, but more importantly to embrace the fundamental concept of sustainable agriculture—a concept that says we must balance the needs of future generations with present needs and pursue an agricultural development strategy that will preserve the natural resource base upon which future food must be produced.

Thank you very much.

Mr. HALL. Thank you, Mr. Grove.

Mr. Mellor, you talked about your strategies for the long-term, which is absolutely vital if we're to end this tremendous hunger program we have in the world.

But my question is: Are your three pillars of development applicable to short-term? And if they are, how would you prioritize them and allocate the resources?

Mr. MELLOR. I think they also offer the best prospects for the short-term, but I would like to emphasize that the infrastructure push, getting all-weather roads out there so people can communicate with each other, and get extension, and learn about birth control, and so forth, and so on. That's a very labor-intensive process. And in poor countries, labor-intensive means food-intensive—that when you hire a poor rural person to work on a labor-intensive road, 60 percent of that expenditure is going to be for food—you're paying labor and the labor is going to spend most of that income on food. So there's a tremendous scope for increasing the quantities of food aid used in order to provide that physical infrastructure.

We can say the same thing about education. Probably the most difficult problem in getting poor kids into school is that poor kids have things to do to keep the family alive—they're herding cattle, they're scratching up some—scavenging some grasses here and there for cattle; they're trying to find some food here and there, and so on, and they don't have time to go to school.

If you have a school lunch program, you are providing a good deal of the food not only for that child, but you're relieving the family of a burden, so that it's less necessary to have that child out scavenging.

So we could use food aid very effectively in dealing with these long-run problems of education and physical infrastructure, and in using the food aid to do the long run problem, have an immediate feeding of people in the process—so you can get at the short run problem.

Let me just add on that, that if a person from Mars came down and saw that there's lots of surplus food over here and there are hungry people over there, and heard that there was a big lobby saying, it's bad to move that food from here over to those hungry people—the person from Mars would wonder what kind of a world is this?

But we have a lot of that. A lot of people saying it's bad to have food aid.

Why don't we recognize that there's some food, here's some hungry people; there's some roads that need to be built—but why don't we figure out ingenuously how to see to it that food aid is used in an effective way, as it has been—as has been the case very often, but not always. So you can get at the short run through this process.

Mr. HALL. Let me follow up with that. A specific country like Laos, for instance, actually doesn't have the roads it should have.

Mr. MELLOR. Yes.

Mr. HALL. If they could grow crops, they couldn't get their crops out, I was told when I was over there. So as a result, they grow the—what's the plant called? They grow it, I can't remember what it is called. But the fact is that there's no market, there's no

bridges—you're going to cross the river. So there's no infrastructure.

But at the same time, though, there doesn't seem to be a market. But the fact is that that's a very fertile, fertile land.

Mr. MELLOR. Yes.

Mr. HALL. But how do you develop a strategy for us to push them, or multinational banks to push them, and to help them to build these roads so that these farmers, instead of growing the drug crop, can get their corn, or wheat, or whatever they're going to grow—rice, et cetera—out of there?

It seems like this could be the answer to a lot of different kinds of problems, not only the hunger problem.

Mr. MELLOR. Let me say that you have large numbers of very poor people in countries that are much further along the path toward development than Laos. So that we can talk about the programs that I'm laying out here coming in and having a rather immediate impact.

When you move to the least developed countries like Laos, things are going to sputter a bit as you move along. But even in Laos there is an indigenous structure that can be used to organize to get jobs like road-building done, and schools built, and so on. So there is some structure there—you have to utilize that structure at the grassroots level, and use the PVO's along with other institutions to do that, and get people to work building those roads, getting those schools operating.

And you've got to introduce the process of technological change. They've got to get a high yielding rice variety suitable to Laos, which means their agricultural research system has to be rehabilitated. We're not working on that very effectively now. We used to, but we don't anymore.

Mr. HALL. Mr. Grove, you talked about a lot of different technologies and the importance of biodiversity. It's a similar question: How do you get the countries to not only understand these ideas, but to implement them; then how can we as a country encourage this?

Mr. GROVE. I'd like to reinforce the comment that Dr. Mellor made in his opening statement. One of the things I think we do best as a nation is we provide the educational base for training the inhabitants of developing countries.

And if we are going to train inhabitants of developing countries and help them learn how to protect their own natural resource base, we have to first change the way we manage our own land grant. Sustainable agriculture is becoming more and more of an objective within the land grant system but it still has a long way to go. And in my opinion, we haven't yet done a very good job of exposing developing country scientists to the concept of sustainable agriculture.

Mr. HALL. Question.

Mr. MELLOR. I have something on that, that one of the problems with the practice of sustainable agriculture is, it is in a management sense more complex. We start out using no fertilizer and just throw it on—you can shove the yields up substantially but you will get a tremendous amount of runoff and so no.

As soon as you start telling the farmer that if you want more efficient use of that fertilizer, it's got to be placed in the right place, it's got to be put on at the right time, it needs soil testing, and so on—you need a complex institutional support system, which we have in the United States, and you need an educated farmer.

What I'm saying here is that for sustainable agriculture to really move, given its complexity, and it will become simpler, no doubt, as time goes on—but it starts out very complex. We need a total development process in which you can afford to educate people, and educate the rural people, and are building public institutions for soil testing and educating farmers.

So that we aren't going to be very successful with these complex sustainability objectives if we just feed it into a static kind of a country where education isn't moving ahead, where roads aren't getting built, where development isn't going on.

What I'm talking about and what he's talking about go hand-in-hand.

Mr. HALL. Questions for the witnesses, Mr. Penny?

Mr. PENNY. I don't have any questions, Mr. Chairman. But I want to say that the testimony is very helpful, and a number of your specific recommendations. I would hope that we could begin to pursue this long-range commitment. I see you've highlighted Southeast Asia, Africa as priority areas.

I've taken an interest in Central America, and I was just reading with dismay the story in the Washington Post this morning where we're back to a policy of neglect as it pertains to Central America. I suggested, and I think others in this room suggested a year or more ago, that as soon as the dispute within Nicaragua is settled, we're going to forget about Central America. And here we are a year later, and essentially that's what we've done. But these are the kinds of long-range commitments that we need to make with our neighbors to the south.

I know that the whole function of this committee is to network with foreign aid and agriculture and others, and I think your study is right on target, and I appreciate your presentation this morning.

Mr. MELLOR. Thank you. Could I just comment on that—that Costa Rica is part of Central America, and if we want to see how they do it, it's not a bad place to look. A lot of things I'm talking about are being done fairly well there. And they have a little democracy also, which I think helps.

Mr. PENNY. I've been there and——

Mr. MELLOR. That wasn't a put-down; it was a put-up, I think. But there is hope in Central America.

Mr. HALL. Mr. Emerson.

Mr. EMERSON. Thank you, Mr. Chairman.

Dr. Mellor, thank you very much for your statement and for the paper which you have submitted which I look forward very much to reading.

I'm always glad to see blueprints and implementable programs, and I'm really looking forward to this.

Mr. MELLOR. I hope it is.

Mr. EMERSON. We had yesterday Chairman Hall and I spoke at the opening of a symposium on infant mortality. And I think the chairman made some profound points about one of the problems is

that we're not well coordinated in our efforts to address the problem.

There are extensive Government programs to address and come to grips with the problem—and so many good efforts in the private sector that are beneficial and worthwhile but are disjointed and uncoordinated with and among themselves, and with the Government program. We need to find hopefully in finding a way to be better coordinated and integrated in our approach to avoid massive bureaucracy that becomes all consuming.

So, you know that same principle that the chairman talked about yesterday, it would seem to me would be applicable to the world hunger scene. So I'm interested in your comments, Mr. Grove's comments, about is the government structure—is it adequate as we look at world hunger problems, and are we well enough coordinated with the NGO's and the PVO's? Are we all really pulling together in order to do the most effective job possible with available resources?

Probably an across-the-board answer to that is, no, never, because we're not perfect.

But do you think we're moving in the right direction?

Mr. MELLOR. The nice answer to that is that most Asian countries have been moving sufficiently in the right direction so the results are beginning to show, and in some cases they're dramatic the way they show. So, sure.

In Africa, the independence came much later than in Asia, so for that reason alone they're further behind. They came into foreign aid when foreign aid was sort of shifting from one short-term fad to another, so they didn't get a very good deal on foreign aid in Africa.

But I think that's beginning to sort out somewhat also. So, yes, I think we're slowly learning and improving.

I have a little hope at the moment that I think we're getting ready to get some real results.

Mr. EMERSON. Good. You touched upon many areas that evoked some memory of the past or some concern that has crossed my mind at one time or another, and I work on hunger—you know, when you talk about building roads and the need for them, infrastructure needs—I've always found whenever I've seen a bona fide famine anywhere that my impression was it wasn't the lack of food in the world, it was an infrastructure and a distribution system that was lacking in order for us to deliver the food to the people.

It's sort of like oil crises in the United States. We worry about it when there's all of a sudden not enough. And then the crisis of the moment passes and we don't worry about it anymore until the next crisis comes along; and in the meantime we don't do anything for energy independence.

And so it is with famines. I've had personal involvement in the last couple of famines in Ethiopia. There was an interim period between the famine of 1984 and the famine of 1989. I'm not sure much happened to address the problems that could were identified.

And on the other hand, I don't know how you build roads in Ethiopia. When I came back from there in 1984, I said—because my district's on the Mississippi River, and I had a lot of dealings with the Corps of Engineers—I said, the Corps of Engineers could

have a field day if we sent them to Ethiopia because there isn't anything engineering-wise that they don't need over there—and that's the truth. But the cost—the expense.

And that leads to another thing, is to how much are we justified in imposing ourselves, with our solutions, on other societies and other cultures? I really wonder.

You know, there are a lot of ethical and moral questions involved here, and I've never really quite settled on where we ought to be addressing the problems. But are we doing—you know, the Africans, in particular, say, rural tribes, people who are agrarian in their orientation—should we be trying to teach them our ways, or sharing with them technology that we have that might make their way easier and more productive?

Another thing—we give aid to some of these countries and it winds up we're promoting the development of some industry in a city. So people go from the countryside to a city, with which they're unfamiliar—there's a disorientation there—and we may encounter hunger and poverty in the cities. And these people have gone from one environment where they may have been comfortable and may have been able to sustain themselves, into an environment that is alien to them and where they can't sustain themselves. And we're hastening that.

What level of thought and responsibility should we be giving to those questions?

Mr. MELLOR. Let me say on that—I'd like to be slightly personal on this. I studied in England for sometime. I don't think that removed me from my cultural heritage. I lived for a long time in India—I think I'm still an American.

Why do I say that?

Because we have a lot to offer the people of other countries. We know how to achieve anybody's objectives a lot more efficiently than used to be the case in the world. Bring those people here, let them study here, let them get Ph.D.'s in soil science, plant breeding, and what have you—and go home and figure out how to adapt that to their circumstances and whatever objectives they have.

And we get a lot of talk that people from developing countries come here and they just pick up our values. Well, to some extent they do—and I'm not sure that's so bad. It was their choice to pick them up. I don't think we're perverting people when we bring them here.

They come here, they see; they go back to their own cultural heritage they were brought up in and they figure out how to adapt it to those circumstances.

So I'm a great believer in all this—I'm a great believer in that sort of thing.

Let us help them build educational institutions. Let us help them look at what we do here, and then let them figure it out.

My observation is they figure out doing things that aren't radically different to what we do. Well, that probably means that we have similar genetic stock in each case. And when we became more efficient and more wealthy, we decided we wanted to do things this way. It's not terribly surprising if when they become more efficient they want to do many things the same way. But they'll do some things differently along the way; and they may learn we made a

few mistakes along the way and avoid them. But let's help educate them.

Mr. EMERSON. Mr. Grove.

Mr. GROVE. Yes, I think one of the lessons we might take is the tremendous success of the NGO and PVO community. I think one of their successes has been that they've taken knowledge and training, but they've listened to the people who are going to use it, and they've helped them adapt it.

I think we need to do the same thing in our educational system as we help developing countries build their own human capacities, just to make them sensitive to the needs of their own cultures and their own people.

I think perhaps we sometimes are guilty of imposing our own technological processes rather than the thought processes that lead to technical techniques.

Mr. EMERSON. Thank you.

Mr. HALL. Representative Long.

Thank you, by the way, for starting the committee here.

Ms. LONG. Thank you.

Thank you for your fine testimony.

Before Mr. Penny left, four of the five of us who are here today serve on the Agriculture Committee as well as the Select Committee on Hunger. I was up pretty late this morning—I think the two gentlemen, Mr. Emerson and Mr. Smith, were up until about 4 o'clock this morning working on the 1990 farm bill.

We obviously have a joint interest and see a relationship between ag policy and hunger. And you also in your testimony indicated that you think for developing countries to be jump-started that it's the agricultural sector that's going to have to do that—I think you used the word "engine" or something.

My question to you is, in light of all the budget cuts that we have to make and changes in agricultural policy and food policy, what do you see that we should be doing as a country in agricultural policy, or in food policy, that would not only benefit us domestically but would help fight the world hunger problem?

Mr. MELLOR. That is, of course, a problem I know you have been wrestling with for a long time and I am not going to have a simple answer for you in this particular few moments, but I would like to say a word or two about it.

First of all, as I think a number of you know, I play a role in the sense of discovery that those poor countries that do well in moving their agricultures along quickly become very good markets for our agricultural exports and I think that is one of those wonderful situations where we can do well by doing good in the world. We help them develop their agricultures. They, in general, are land-short countries and as they prosper and particularly as they begin to introduce some animal protein into their diet, which may be bad at the level we are doing it, but it sure is good at the level from which they are starting. As they do that, we begin to get a very large feedgrain market out there and we get a market for some other things that we produce in our agriculture.

We should have an interest in long-range market development in developing countries which we achieve by helping them to grow and producing food to help get them out of hunger in the short run

so that they can start to prosper and become a market for us in the longer run. We do that by helping with technology. We do it by being a reliable supplier and I think we want to be very careful that we don't play a role in making this a world where food supplies are a lot less stable than they have been over the last 20 years.

I think that as we see global stocks coming down, we want to be very quick to bring land back into agriculture, to keep some decent stocks on hand so that countries will be encouraged to go ahead and inflate their demand for food and to feed their people better because they know that there will be a supply of food there if they suddenly run short.

We need to share our land-grant college capabilities with other countries, to share that science and technology with them.

I was very struck yesterday—I was out in Minneapolis at some meetings, and Charlie Hess, from USDA, was there. He talked about sharing technology from the other side, that from the international system of agricultural research, how much the United States got out of it and how important it was to us to do that. So it is a two-way street.

We have one world; we ought to be playing in it.

Ms. LONG. If I could ask a follow-up question then, how can we tie in foreign policy, and particularly foreign assistance, tie that into all of this?

Mr. MELLOR. I would have hoped that this extraordinary turn of events which we have had in the world with respect to the Soviet Union and the Eastern Bloc would allow us to take a little broader look at what our international interests are and that they aren't now simply cold-war politics, but trade and raising prosperity in the world and what role can we play in seeing to it that other parts of the world prosper so that we can share in that prosperity and, you know, one of the things that we tend to forget is that we had a tremendously prosperous period in the early 1960's. Why is that? It is basically because Europe and Japan got going. They became more productive. We traded with them and we got something from their increased productivity and that added to our prosperities in the early 1960's.

We now have a chance of seeing incredibly poor people in the world starting to prosper and you might say, gee, do we really want to benefit from their growth? Well, why not? We are going to trade with them; they will prosper even more as a result of that trade. We will be buying some things cheaper than we would have bought them otherwise. We will prosper from it.

So we need to start looking at that issue. How do we get growth going and, if I could just take one sentence to return us to what this testimony today is about, remember that I said that countries like Brazil and Indonesia and Thailand and Malaysia and the five prospering states in India and so on, when those places began to prosper, hunger plummeted and plummeted from very high numbers.

So we are talking about a wonderful process here in which we get rid of hunger in a way that is sustainable. It is not just a matter of handouts and so on.

Ms. LONG. Thank you.

Mr. MELLOR. Thank you.

Mr. HALL. Representative Smith.

Mr. SMITH of Oregon. Thank you, Mr. Chairman.

Dr. Mellor, interesting testimony. I don't know whether you used the example, but an obvious example of your testimony today is the lack of roads and a transportation system in the Soviet Union.

Mr. MELLOR. Yes, it is incredible.

Mr. SMITH of Oregon. Fifty percent of their crop will stay in the field and yet, they are standing in long lines.

Mr. MELLOR. Yes.

Mr. SMITH of Oregon. They built one of the largest, most fierce military strategies the world has ever known and yet, they don't have transportation to bring their goods to market. A perfect example of——

Mr. MELLOR. It is absolutely unbelievable, but true.

Mr. SMITH of Oregon. I wanted to ask you——

Mr. MELLOR. That means their situation is not going to turn around overnight because you don't build all those roads overnight.

Mr. SMITH of Oregon. Of course.

In your final point, you say, "In the final analysis, our assault on world hunger can only succeed if fueled by a major relocation of foreign aid." In your testimony, you continue to say A.I.D. must get back to the fundamentals of the system, research, engineering, education. That sounds like a criticism of what we are doing.

What should we be doing that we are not doing?

Mr. MELLOR. I think that—I want to be very clear that, as I was in my testimony, that the——

Mr. SMITH of Oregon. Go ahead and criticize, I don't care.

Mr. MELLOR. Sure, but I think the basic thrust of being concerned with big issues of democratization, macro policy, privatization, those are important. I have no question about that and I say that even on the privatization as a person who understands very complex things that governments have to do with the private sector to prosper.

Having said that, I think that the whole foreign assistance community, not just A.I.D., but the World Bank, the other international financial institutions, got so taken up in these broad macro issues that they have lost their touch with the capacity to do the projects which are what development is all about.

I mean, in your district, it is not the price level that determines whether you get a road or not, it is whether you decide to appropriate for a bridge and so on and whether somebody designs the bridge, et cetera. Finally, you have to get back to those projects.

The whole international foreign assistance community has gotten away from that so that they are very short of technical people For example, A.I.D. has very few technical agriculturalists nowadays, as compared to 20 years ago. Something like 70 percent of all the technical people in the World Bank are retiring within the next 4 years. They have an age distribution problem. So the capacity to do projects in agriculture, to build an agriculture university, to do research in sustainable agriculture, whatever it may be, all of that has declined very much, and I think that is very unfortunate.

So when I say get back to it, I really do mean get back to it. We used to do it well and we don't do it very well.

Mr. SMITH of Oregon. Is there any coordination in your opinion between philosophies of Food for Peace, A.I.D., and the World Bank? Is there a direction that all of them are focusing, or are we going willy-nilly? One agency has one developed idea or purpose and another has another and we go about it shotgun style.

Mr. MELLOR. I think the thoughtful thing to say on that would be that the world got so out of whack on macro policy that everybody got focusing on that and the unifying concept across foreign assistance agencies is how do you get the macro policy in shape, get the exchange rate shaped up, agricultural prices shaped up and so on?

At the present time, in foreign assistance, we really don't have a strategic sense as to what you do once you get those broad macro policies straight. If you looked at it from the point of view of the United States domestic policy, we have some big macro policy problems. Once those get straightened out, we have to get back to the real business of development, which is lots of nitty-gritty things. That isn't happening and there is no——

Mr. SMITH of Oregon. We do that.

Mr. MELLOR [continuing.] And we don't have that strategic sense and I would say that neither A.I.D. nor the World Bank really have a strategic sense as to how we move in the nitty-gritty of development once we get the broad macro policy.

Mr. SMITH of Oregon. Let me ask your opinion about a current issue.

Mr. MELLOR. I may lose my next A.I.D. grant out of this, but that is life.

Mr. SMITH of Oregon. That is quite all right. Criticism that is honest is always valued. [Laughter.]

The current issue—a lot of money is floating around the world for the Middle East. We are forgiving—suggesting to forgive $7 billion in debt, for instance, to Egypt. Egypt doesn't have enough money to meet their GSM 102, 103 commitments to us to buy wheat. They go to France and pay cash and buy wheat substituting for wheat from this country, which hurts our farmers and help them.

Why aren't we, as a policy, forgiving some commercial debt to Egypt, a portion of it, $2, $3 billion, a quarter of it, so that they in turn can renew their credit position, buy food from us, satisfy their problem and also help the American taxpayers reduce the CCC commitment?

Why are we doing that?

Mr. MELLOR. You are asking that of a guy who was driven out of farming in Vermont by a banker, OK, so I have a populist view as an answer to that.

Mr. SMITH of Oregon. There is a very cheap cattle ranch you can buy, Dr. Mellor, in Oregon, if you would like. [Laughter.]

Mr. MELLOR. I am not unhappy in my present job, but I wouldn't mind being a farmer. [Laughter.]

Mr. SMITH of Oregon. I am asking your opinion on a mix of forgiveness of commercial debt while we are forgiving military debt. I mean, it is still debt forgiveness. That is a policy we ought to follow?

Mr. MELLOR. If I can give a serious response, which a lot would consider irresponsible, but this is a funny country that—we have

probably the greatest reverence for property rights of any people in the world, and I think for good reason. We also have very encouraging bankruptcy laws which are an appropriation of somebody's property, right? I think those two go together. I believe in bankruptcy laws. When the bankers screwed up making a loan and you screwed up, you have to write it off and see whether you can start over again.

I am trying to avoid being frontal in agreeing with what you are suggesting, but——

Mr. SMITH of Oregon. Why would you want to disagree with me when I am correct? [Laughter.]

Mr. MELLOR. There needs to be a writing down of debt in the world and it is too bad we don't seem to be——

Mr. SMITH of Oregon. I am not criticizing writing down. I am saying, when we do it, why aren't we forgiving some commercial debt along with military debt, which it seems to me benefits——

Mr. MELLOR. I think the technical answer——

Mr. SMITH of Oregon. Your purpose——

Mr. MELLOR [continuing.] To that is we don't have very good mechanisms—within this country, we have mechanisms for writing down commercial debt, which are part of the law and agreed to, we don't have similar mechanisms in the international round. Again, it comes back to the hunger issue that there is no question that the fact that a lot of foolish debt was—and I think it is fair to call it foolish debt—was taken on by a lot of countries, is now creating problems which clearly is adding to hunger in the world. I believe a lot of those UNICEF figures that come out and what this does to children and so on.

We need to be a little more ingenious than we have been about an overall overt writing down so we can get on with the job of development again.

Mr. SMITH of Oregon. Mr. Grove, do you want to comment on any of these discussions and questions?

Mr. GROVE. I would simply say that in reference to the debt issue, of course, there are a number of figures in the literature that show that debt is driving most or much of environmental degradation in the world and it is the only resource that many of these countries have to pay their debt, is to exploit their renewable natural resources.

I support any effort to get rid of it.

Mr. SMITH of Oregon. Thank you.

Mr. HALL. I want to thank both of you for your testimony and your work and we continue to look forward to your input in working together with you. Thank you.

Mr. MELLOR. Thank you very much.

Mr. HALL. The second panel consists of Paul Faeth, who is an associate at the World Resources Institute. He will be talking about his current research on sustainable agriculture around the world; and Mr. Peter Carlson, chief scientific officer at Crop Genetics International, which is an agricultural biotechnology firm which he founded in 1981. He was previously a professor at Michigan State University and will be talking about the most recent developments in the field of biotechnology.

We will start off with Mr. Faeth first.

STATEMENT OF PAUL FAETH, WORLD RESOURCES INSTITUTE

Mr. FAETH. Thank you very much, Mr. Chairman.

Let me begin by thanking you for inviting me and offering me the opportunity to express my opinions on agriculture sustainability to this select committee.

There has been—if you look at the field of sustainable agriculture developed over the last few years, there has been a struggle, if you will, to define exactly what sustainable agriculture is. Most of these definitions include some aspect of maintenance of agricultural productivity, maintenance and improvement of farm profitability and maintenance of natural resources.

Unfortunately, most of these definitions have been of a qualitative and not a quantitative nature, so, in the sense of their usefulness, they have been conceptually, but not operationally useful. The definitions have not been of great use to policymakers and to researchers who have tried to determine whether the impacts of agricultural policy and agricultural research—on natural resources.

Sustainability means that economic activity should meet the needs of the present without sacrificing those of the future. In the basic accounting and economic textbooks, you will find the definition of income that meets this definition, maximum income that can be consumed this year without reducing potential income in future years.

On the face of this, that is a very good definition and meets what we would define as sustainability, but unfortunately, the way that this definition has evolved since the years of the Great Depression, this has focused on man-made plant and physical equipment and not on natural resources. Natural resources have, in fact, been left out of this definition.

Tractors and barns, for example, depreciate and there is an allowance made for that in current income to maintain that equipment, but if soil is degraded; water is polluted or wildlife habitats are destroyed, we ignore the loss. Yet, these are as sure an economic loss as is the loss of productivity of a tractor or a barn or any other physical man-made asset.

This false dichotomy has led to an implementation of policies, and pursuing of research agendas, that discourages and has often ignored resource-conserving agricultural practices.

At the World Resources Institute, we have a study on agricultural policy and its impact on the adoption and generation of resource-conserving practices, which includes, for example, a soil depreciation allowance as soil becomes less productive, or an appreciation allowance if particular agricultural practices improve soil productivity, and off-site costs that are not borne by the farmer but, instead, by society.

These U.S. case studies bracket the Nation in the sense that in one case study in Pennsylvania, has among the highest resource costs of agricultural practices in the United States. A ton of eroded soil can lead to more than $8 of off-site damages in the area because there is a high population concentration and high value on water resources.

In our other U.S. case study in Nebraska, just the opposite is true, that soil erosion leads to only 66 cents worth of damages off farm.

Additionally, the soil resources in Pennsylvania are less robust and more prone to degradation where the soil resources in Nebraska are very robust.

In looking at these case studies, I should mention that we have a number of other case studies throughout the world that I'll talk about in a minute, in India, the Philippines, Australia, Chile, and we're trying to put one together in Mexico.

Research in this area shows that current policy in fact is unsustainable and that it discourages the use of resource concerving farming systems, and encourages the use of farming systems that result in off-site damage and depreciation of soil resources.

In looking at alternative policy scenarios, it's generally true, not only in the United States but in other situations, that policies that mask the prices that a farmer would pay for a resource encourage over-use and lead to less sustainable use of natural resources.

This can also lead—for example, in our situation—to higher costs to taxpayers, less net social benefit to society as a whole, and in fact, less net income for the farmer.

In our less developing case studies these, again, form a sort of a continuum. If you look at, for example, India, their agricultural inputs are very highly subsidized. In fact, the energy for irrigation, pesticides and fertilizer is subsidized by as much as 90 percent. In the Philippines there is less subsidization but still quite a bit. And in Chile, there are almost no subsidies for agriculture.

On the commodity price side, in India, farmers face a very severe price cut for their crops. The USDA has done studies which show the overall subsidies for an Indian farmer is a negative 40 percent—in effect they pay a 40 percent tax on their production.

In the Philippines, this is not quite neutral but there is an effective tax. In Chile, there free-market prices prevail.

What we see in this set of case studies is that there is significant environmental degradation occurring in India of all different sorts. There is groundwater depletion in certain areas, soil degradation in other areas. Pests have become very resistant to the pesticides that India has available to use and soil is degrading to the point where in fact in many areas that have been the most productive, they are seeing an inability to maintain increases in yields; and in fact, yields are beginning to slip somewhat. In the Philippines, this situation is also true.

IRRI, the International Rice Research Institute, has said that on the best agricultural farms around their experiment station there essentially is no gap between their experiment station yields and the yields that they're seeing on the farmer fields, and there is no expectation of future increases in yields in these areas.

That's kind of scary because in the Philippines in particular, where population is growing, they're seeing the need to increase from four tons per hectare per year average rice production to five in order to maintain self-sufficiency in rice production.

In Chile, on the other hand, where there is almost no distortion in the agricultural sector, farmers are very quick to respond. And in fact over the last few years, for a variety of reasons, many grape

growers have gone from conventional agricultural practices relying heavily on pesticides, for example, to almost organic production of grapes.

In general, as I said earlier, if resource use is subsidized, if someone else pays the cost of resource use, then farmers won't use those resources efficiently and sustainability will not be the result.

If you look at trends in agriculture and in population growth around the world, there are essentially divergent trends where we're seeing still rapidly growing populations while environmental quality is essentially trending in the opposite direction. There are more people, but our natural resource base is being degraded.

Future production and future production increases will be dependent upon a healthy natural resource base. Past production, however, has often been unsustainable and many problems maintaining productivity in yields, have been seen in many areas of the world.

Some say that natural resources and technology are substitutes; in fact, they're complementary. Technology improvements are dependent upon a healthy natural resource base; and without a healthy natural resource base future increases in yields and productivity will not be seen.

It is invariably true that more potential agricultural production can be achieved with a healthy natural resource base.

It is crucial to maintain the productivity of natural resources in order to realize the potential of future technical advances in agriculture. I suspect we will hear in a minute in the area of biodiversity which is essentially the feedstock for improvements to biotechnology and other means of plant breeding and such, biodiversity is a particularly important area that will allow future increases in agriculture production.

As if the problems that we're facing now aren't enough, many climatologists suggest that global climate change will make things even more difficult. Climatologists expect to see more variability in rainfall, more drought in certain areas, such as the Midwest in the United States and the Indian subcontinent; and higher temperatures.

If we had a healthy natural resource base and we were on the footing of sustainability, it could be relatively easy to adapt to that situation. For example, within about 10 years, agronomists say that we could produce new crop varieties that could deal with somewhat less water availability and stress produced by higher temperatures.

But if the resource base is not robust, we are not on a sustainable footing, this will be a much more difficult task.

Conventional agriculture is conventional due to the agricultural policies that we currently have—not only here but throughout the world. Subsidies on energy and water, for example, make it difficult for farmers, make it unprofitable for farmers, to adopt water conserving agricultural practices.

It doesn't make sense to adopt, for example, integrated pest management strategies or strategies such as crop rotations to reduce pest stress, when pesticides are heavily subsidized.

Similarly, for subsidies on fertilizers, it doesn't make sense to adopt integrated fertilizer management strategies or to use significant amounts of green manures when fertilizers are much cheaper.

Not only does policy make it difficult for farmers to adopt existing practices that are resource-conserving, but also the generation of those practices. Research chases essentially what are the less expensive inputs to production, and if policy makes inputs artificially cheap, research follow those practices of production which are less expensive.

So, for example in the post World War II era, where there had been heavy subsidies for energy and pesticides and fertilizers in many places, research has followed these—and it has been sort of a loop where they become less expensive and more research is followed in that area.

Resource-conserving agricultural practices, on the other hand, have not been favored by agricultural policy and as a result, there hasn't been much research effort put into those. Now that's not to say that the technology that we've seen, such as fertilizers and pesticides, haven't been a boon—they've been a tremendous boon to us in terms of increased food productivity. It's just that along with that we haven't seen similar increases in technology to conserve resources. Resource-conserving agricultural practices have been to a large extent ignored by research establishments.

The first and most essential step that we should take to ensure agricultural sustainability is to ensure that agricultural policies encourage the adoption of resource-conserving agricultural practices. And really the only way to do that is to begin by taking into account and treating natural assets as if they truly were assets and not, as I've seen on a bumper sticker, "Treating soil like dirt."

Thank you.

[The prepared statement of Mr. Faeth appears at the conclusion of the hearing, see p. 61.]

Mr. HALL. Thank you.

Mr. Carlson.

STATEMENT OF PETER S. CARLSON, CROP GENETICS INTERNATIONAL

Mr. CARLSON. Thank you, Mr. Chairman and members. I appreciate the opportunity to have a chance to give you my views.

I think the prior witnesses have outlined the problem very well—of poverty, food, sustainability, natural resources. I'd like to treat a much more narrow point, really with two components.

What is the role of biotechnology in sustainable agriculture? And what is the role of the private sector?

It is my opinion that over the next several decades, the focus on biotechnology will be to improve crop health and to protect crops from diseases and pests. And this is certainly an important component in developing better crops and reducing the level of pesticides. Essentially what we're trying to do is to substitute biology for chemistry in crop protection.

My company has been in business for the last 10 years, and I've been in this field for the last 20 years. It is not trivial to get an idea of where biotechnology will fit. Actually, biotechnology is a science that has great expectations. Many consider it to be a silver bullet or a panacea for all the problems of agriculture. That is not true.

Biotechnology is a series of tools of techniques that allow us to do particular things. Oftentimes in policy discussions, individuals have a Rorschach test—and what they see in biotechnology is really a function of the problems they have at hand; they'd like to have a solution. But that's not what biotechnology is.

Biotechnology is not a revolution; it is a evolution. It is a step-by-step process trying to take conventional needs and solve them in a prudent, effective way with new technologies.

In this country, my particular company has been involved in trying to look at the problems of plant health and resistance to insects and disease. Biotechnology gives us new tools. With these new tools we can have different approaches to the problem.

One problem that we found was in sugar cane. Sugar cane is perhaps our only major crop that has no seed industry. Henry Wallace was really the last one to start a new seed industry back in the 1930's when he founded Pioneer Hybrid International—of course a major component in Midwest agriculture.

But sugar cane has been a neglected crop, but cane has the same kinds of problems as corn, soy, and other crops. But cane is not planted as a true seed. You don't have a hard kernel that's put in the ground. What is put in the ground is a long stalk of the maternal tissue and progeny result from growing the nodes. So functionally it is a perennial crop—a crop that is propagated by planting the mother. That allows diseases to be transmitted from the mother to the progeny generation after generation.

Consequence: diseases build up, yields come down. So that when a new variety comes on the market initially it performs very well and over time its performance comes off.

Is there a new tool from biotechnology that we could use to create a new seed business?

Well, we've done that—it's called tissue culture. Using tissue culture we can take small pieces of elite varieties from Louisiana, Florida, and Hawaii, and culture thousands—literally hundreds of thousands of plants from an individual parent stock—and each of those plants are now disease-free because they've come through sterile tissue culture.

These plants can be transported around the world very nicely in any plastic containers. I've got an example here. Here are some plants produced in our laboratory by technicians who are very skilled. These are little sterile greenhouses and these can be transported worldwide from one country to another, from one State to another.

What we do in Maryland is we have a small number of major Louisiana varieties. We use tissue culture to produce hundreds of thousands of these plants and we ship them to Louisiana and Florida. These are then put in the soil and whole plants are grown from these. These are very vigorous plants because they are disease-free—they've been rejuvenated.

These whole stalks that are cut and sold to the farmer—the product is a whole stalk of cane. Now the farmer produces for himself seed of the same varieties. His seed has disease; our varieties—our stalks—are disease-free, and the consequence is about a 27-percent increase in yield. It's a nice business because we can create

value with biotechnology. It's a simple technology. It's not revolutionary; it's evolutionary.

Would this technique work throughout the world? Absolutely.

Would it be of importance to stimulate agriculture? Absolutely, because these particular clones do not require the use of fungicides and other kinds of chemical agents.

So there are simple techniques that can be used. I must say that one thing we've learned is that science must be routine. For it to have an impact you don't want science to be done by scientists; you want it to be done by technicians. These plants can be produced by anyone who has a high degree of manual dexterity. If you can sew, if you can knit, if you can work an abacus, you can produce these kinds of plants on a large scale.

In addition, this technique is appropriate for any crop that's propagated vegetatively and we all know in a developing world most crops are not seed-driven crops, they are bananas, they're yams, they're cocoa, yams, and they're also cane.

This is a technology that's here and now. It's not star-spangled, whatever, but it's real, and it works, and it does create value.

One thing we also learned in this business is it's awfully tough to ship this technology abroad—and I'll get to that in a while.

After we had developed our sugar cane business, and we're now making a profit on this in our Louisiana market, we came to the conclusion that as a small North American company we have to deal with North American crops because there are not very many acres of sugar cane grown, and so we have a limit on the kinds of business that we can have.

So we decided to look at corn. Corn is our major North American crop. And we asked, where can biotechnology have an impact? Right now in corn production, to protect the crop you can either breed new varieties—and that means taking different inbreeds and producing different hybrids, have different characteristics—or you can use the techniques of molecular genetics to insert new genes into these corn crops. These new genes then, over time and breeding, can have an impact and increased yield. That's one issue.

The second way to do it is to spray on a chemical. Spray on a chemical that would increase yield either by being a fertilizer or being a fungicide or being an insecticide—any one of a number of ways.

But biotechnology as a new science gives us an opportunity to create new ways to solve problems—and that's what we call our InCide business. We asked ourselves a very simple question: If you can vaccinate people and animals, why can't you vaccinate plants?

Well, plants don't have an immune system. And as a consequence, you really can't make them vaccines. But just because they don't have an immune system, doesn't mean you can't give them one. What we wanted to do was to develop the functional equivalent of a vaccination—that is a small amount of a biological, delivered early on in the life of the plant, that would give lifelong protection to that individual plant, but not to the next generation.

Repeat sales is important in business. We wanted the farmer to come back more than once to buy this particular product. We could create value by putting on nanogram per acre and a scale-up would

occur in the plant during the growth of the plant but it would not be transmitted. This really is our InCide biopesticides.

We give the plant an immune system and we give it an immune system by taking microbes of ordinarily live-in plants and cause no consequence to those plants.

Now before the tools of biotechnology, these microbes didn't have any consequence—no one studied them. It didn't cause disease so you didn't get tenure in a department of plant pathology by something that had no consequence. But now that we have the tools to give these endophytes the ability to do something—and that something is determined by genes that come from many other microbes—to be an insecticide, to be a fungicide, to be a plant growth enhancer—these microbes were a delivery system that then had value.

Well, that's what we did. We thought, we'll develop a plant vaccine and we'll call it InCide, and we'll base it on endophytic microbes that live in the plant, cause no consequence to the plant; but we put something in there, they can have a positive effect.

And we chose to look at the European corn borer, a major U.S. pest that cost about $500 million a year worth of damage in the Midwest. And we have put in a gene from bacillus thuringiensis, a naturally occurring bioinsecticide that's been on the market for the last 50 years—no one's had any negative consequence. It's a favorite of the organic gardeners. Put that into an endophyte that lives in corn, and lo and behold, we can control European corn borers. A nifty product.

And in addition, we have developed a method to deliver this particular vaccine to plants. Now when you say vaccine, you probably think of a scientist in a white coat way out in the cornfield and asking the corn to bend over and take it in the ear, one by one. That's not the way we do it.

The actual way we do it is we work with the seed company in their seed conditioning plants, and we take tons of seed. We put these tons of seed in a solution with buffer and put them into the microbe and push the microbe into the seed so that the seed now has the actual microbes. They only need a few number of bacteria in a seed—and this is so high-tech the farmer won't even know it's there.

But when that seed is planted, the seed germinates, the microbe that contains the insecticide grows along with that plant, and that plant is protected. Now, this is a very nifty technology, and we're bringing it forward here in the first world.

We have two basic problems. The problems are, even though you can do the science, the science really is only a part of the whole operation. Science doesn't exist in a vacuum. Biotechnology does not exist in a vacuum. It exists in a very complex arena of politics, society, and economics, and whatever else.

Because we have used the tools of recombinant DNA, we are regulated by three different Federal agencies—the FDA, the EPA, and the USDA. And these agencies all have very clear roles in registering new products in our country.

The second issue is, this is a brand-new technology. There's no prior art. So we apply to the Patent Office. We apply to the Patent Office and ask for patent protection because no one has ever done

this before and it's a big financial risk for us to go out and really a look at this and see what we can do. Patent protection is in biotechnology not yet mature.

So that's what we're doing. We're doing Kleentek, which is a business; and we're doing InCide, that's going to have tremendous potential and potential beyond corn, because endophytes occur not only in corn, they occur in rice, soybeans, cotton, and wheat, and all the major field and row crops in the endophytes occur.

But the drug companies have for the last 50 years collected bacteria that do interesting things—they make penicillin, they make tetracycline, they make all kinds of insecticides and fungicides. Those are our two raw materials—endophytes of the delivery system and genes from bacteria that really are in the pharmaceutical industry. And that combination can create a whole range of products that can address a number of needs that are now met by either breeding, or spraying, or are not met.

Technology is very powerful. I think in terms of looking at the international implications for this—in our country we believe in the magic of the marketplace. I left the university 10 years ago believing in the magic of the marketplace and it hasn't let me down yet. And we also believe in science. But just because it can occur doesn't mean we can help sustainable agriculture in the developing world. We can really address the food problem in the world. Because, really, transferring technology to the developing world won't simply occur.

Those countries often have different crops, and the technical infrastructure there is embryonic; and there's minimal commercial incentive. Therefore, there's a need for public institutions in those countries and our country to play a direct role in the developing world.

I think that we must harness the private sector in the developed world—in our country, and in Europe, and Japan, to transfer technology to the developing world. It may sound simple but it's much more complex than that. And it really has to do again with two major issues: patents and regulation.

The developing world is under little or no constraint to abide by the intellectual property laws that are available and are enforced in the developing nation. And bringing new technologies, such as these; and I would say that the majority of new technologies are being developed in the private sector, are two developing areas would create an opportunity for offshore competition for our home markets.

How can that happen?

If we look at InCide, since only nanograms per acre are required, if there's no patent protection on InCide, and this technology would, say, be used in rice in Asia, which it could be; and what works for the European corn borer corn will work for the rice stem bore in Asia, those small quantities could be shipped back and be very difficult to enforce.

Because essentially the farmer's field is a genetic Xerox machine—biotechnology replicates itself. And hence, a biotech crop varieties is oftentimes a one-time sale unless there is crop protection, which is not a business that really can give you a decent return.

Without protection or delivery infrastructure, there is no incentive to make a market in these particular areas.

I would say that all of this is talk. We have technology; we can create business; we have new ideas as to how to bring this market. And in the past, we have oftentimes used the private sector as being a nonplayer or being a player only for their own benefit.

I don't think that's true in biotechnology. I think with biotechnology there is an opportunity and there is an enthusiasm on the part of us in the private sector to bring this technology forward—not just small companies, but also large companies.

But to do that what we really need—what we really need—from our Congress, two things: Regulation is not yet written for biotechnology. We have been in the field with recombinant microbes for the last 3 years. Each of those 3 years is a momentous effort to try and get field tests off.

Why?

Because you don't know what the questions are because the rules aren't written; because we are regulated by FIFRA, which is the EPA statute—which is written for chemistry and not biology. And oftentimes what people—be they environmentalists, be they the public, be they politicians, be they regulators—want to see is a Rorschach test that tells more about them than it does about the science.

Make the rules clear. Make the rules tough. But make them clear so you know what the game is you're playing when you get into it. That would make progress go a lot faster. That's one issue.

The second issue is make the patenting situation clear. Right now it is not at all clear what can be patented in biotechnology .

Can you patent the whole process?

Can you patent an organism?

Can you patent the construction?

Decide what it is that can be patented and what is it that can't be patented, so we know what the rules of the game are.

But I would say that once those rules are clear, once we know that we in the first world can register a product—this is controversial—we can then begin to bring that technology to the third world. It will be a mistake for us as a small company to have a technology not yet registered in the first world and try and bring it to the third world. We'd have a tremendous public outburst. And we would also like to have protection of our home market.

But given those two things—regulation and patent—I think that you will find the biotech industry ready and willing to export these technologies and to really help in those areas where the technologies I think will have a major impact. And that is because I think private industry has a different viewpoint that perhaps it has in the past.

And, second, these are not markets for us anyhow.

And let's get the world better fed; let's get on with sustainable agriculture, and let's get on with making the whole process work, because the problems are real.

Thank you very much.

[Material submitted by Mr. Carlson appears at the conclusion of the hearing, see p. 72.]

Mr. HALL. Thank you, Mr. Carlson.

Let me ask you a question, Mr. Carlson, about biotechnology in countries that this committee is used to visiting, like Sudan, Ethiopia, and Mali, Chad. We haven't been to Angola but we hope to before the year's up.

All of them are similar—the erosion of their soil and loss of vegetation, the drought—they all look the same.

Are there any breakthroughs in discovering types of plants that will grow in these kinds of degraded soils—either through your company or in companies that you've heard of?

Mr. CARLSON. No, there are some things that biotech can go right now—they're simple; the baby's got to learn to crawl before the baby walks, before the baby runs. You're talking about a marathon with some of those problems.

Certainly, there can be physically, chemical, and biological inputs into crop protection. And so many of the problems that were outlined by previous speakers are the physical components—soil erosion; awfully tough to deal with. Let me say a cover crop that has certain components—irrigation; awfully tough to deal with in terms of water use—temperature extremes. That is not on the immediate horizon.

Mr. HALL. Is there research going on with it?

Mr. CARLSON. There is research going on but it's awfully tough because these things are all complex. In biology, everything is connected to everything else. You try and change a basic component to the plant and the rest of the plant moves.

There are some suggested new crops for these areas, but that is in my mind nontraditional.

I would also say that there is a great enthusiasm, though, on the part of many developing nations to have their own biotech effort. I applaud that up to a certain point. It seems to me at the current time many of those efforts are premature.

As a practical matter, ag biotechnology is now a first world technology. It won't be forever, but it is right now. This is where the scientists are; this is where the infrastructure is; this is where the new ideas are coming.

I think it is a waste—an unfortunate waste—of effort, money, and hope, and expectation, to try and claim a first world experience in a third world country and expect the same kind of consequence. It will not happen.

There are, however, some routine techniques like tissue culture, which can be easily exported; which can be easily taught; which can then lead to the basis of an infrastructure as you build up to more and more complex techniques. So it is important that you don't do biotech for biotech's sake. And, unfortunately, that oftentimes is the case.

Mr. FAETH. May I address that question, Mr. Chairman?

Mr. HALL. Yes.

Mr. FAETH. Zimbabwe 10 years ago found itself in a similar position to a number of the countries which you named—Zimbabwe was a net importer of food and was reliant on concessional aid. But a few years back they changed their agricultural policy to offer—what ended up being about double their price that they were offering to farmers. It was a very, very low price that previously was offered in order to subsidize urban consumers. And when they dou-

bled the price, production more than doubled. And now Zimbabwe is a net exporter of food in that region.

The farmers respond to proper incentives.

Mr. HALL. I always think of this article I read about some of the soil in the southwest, which is similar to some of the African soil—about seeing some of these weeds pop up when there's no water and they're in the Sun all the time. How do these weeds grow?

I guess that you're taking a culture and trying to put the strength of that particular weed, and implant it into corn, rice, or whatever is indigenous to these nations that we're talking about.

I was wondering if there's any breakthroughs on this?

Mr. CARLSON. Not that I know of. The components that would give a plant drought heartiness would be perhaps a deep root system—many, many roots—the ability to stop growth under tough times and start growth again under good times, and also a perennial nature. Many of those components are awfully tough to duplicate in an agricultural situation.

Mr. HALL. Mr. Faeth, you talked about three nations—about India, the Philippines, and Chile. You talked about good sustainable techniques in Chile, but in the other two nations the production wasn't as good, and there were a lot of pesticides, a lot of subsidies.

How do you convince a poor farmer, or a government, in the Philippines for instance, that the way they're going is wrong and that it's going to be better for them in the long run if they change? How does one go about changing these people?

Mr. FAETH. One of the ways that they're convincing themselves because of—the problems that we're facing—budget deficits. There's a very high cost to maintaining those subsidies in those countries. And the cost at 90 percent, for example, in India, that is not paid by the farmer—it's paid by society. And they're seeing that in many situations, for example, as in New Zealand, which switched over not long ago, not a developing country, but they switched over because they were paying a third of the value of production in subsidies.

And it's getting to the point where in many of these countries where they simply cannot afford it. The Philippines is moving towards removal of subsidies for that very reason.

The second thing, I think, is that in many instances there is the feeling, in talking with researchers in these countries, that resources can be easily substituted for, if you've got a poor soil you can put on fertilizer; a whole range of things that you can do to substitute for degraded resources.

But in fact, certainly it's true for dryland areas that make up 85 percent of the world's production—if you have a soil that can't absorb or hold water, you're not going to be able to realize the potential of that technology.

And there's a growing awareness that in fact the natural resource base is of critical importance and that has to be maintained. And they're seeing in areas where salinization is occurring—they're looking into the future themselves and seeing that they're going to have problems in meeting production, and they simply can't afford to maintain the subsidies to the extent that they have in the past.

That's not such a bad thing because many of the subsidies in fact are captured by the middle class and the rich; and don't go to the poor as they were originally intended. So there's good justification, in fact, in removing some of those subsidies, or else targeting them.

Mr. HALL. Mr. Emerson.

Mr. EMERSON. Thank you, Mr. Chairman.

I hardly know where to start here—certainly it's an interesting afternoon and two excellent panels.

Mr. Faeth, I wanted to ask you just to make sure we're on the same frequency here: When you talk about subsidizing pesticides, for example, are you talking in the sense that that's where research money is directed, or is it some other subsidy that you're thinking about?

Mr. FAETH. Yes, research is focused there. And the reason that it's often focused there is because pesticides are made available in many places at prices much lower than the cost of producing the pesticides. So the actual cost of the pesticide is subsidized by the government and farmers only see a small fraction, in many cases, of the actual cost of the input—as a purchased input.

Because it's so cheap, and being a substitute for other methods, for example, management or rotations, then research tends to follow that because it is such an inexpensive production input.

Mr. EMERSON. You're not necessarily talking about then in this country? You're talking more in developing countries?

Mr. FAETH. Yes, in developing countries. Pesticides are not subsidized in the United States.

Mr. EMERSON. I was curious—you know, environmentally, pesticides are always a subject of concern with the population at large; it's a big environmental issue.

In an agricultural area such as that which I represent, we maintain that there is a very prudent and frugal use of agricultural chemicals because they are a part of the farmer's cost of production. And when times are tight in agriculture, a farmer doesn't necessarily want to add—surely doesn't want to add—to his cost of production, so he's going to apply chemicals in a very frugal way and not use any more than are necessary, and any more than are environmentally prudent.

Would you concur in that?

Mr. FAETH. Right. I don't have any problem with the appropriate use of agrichemicals. There are many situations, though, where there are technologies that could improve the efficiency of use that aren't being used, unfortunately.

For example, many farmers don't do simple soil testing, or don't take a credit for manure that's supplied to fields; so that they tend to overuse fertilizers. And to the extent that those inputs are subsidized by society, you can make the argument that they're subsidized to the extent that any damages, for example, to groundwater which might result, are not borne by the farmer—society pays them.

Mr. EMERSON. Right.

Mr. FAETH. And so to that extent they are subsidized. But the price of the input is not directly subsidized. There are a range of methods that can be used to increase the efficiency and save the

farmer money. There are also cost-reducing technologies for farmers.

Mr. EMERSON. It's a question of how fast we can get from developing technologies to the practical application, among other things. It seems to me there's a long lead time between the development of technology to make them standard practice.

Mr. FAETH. That, in many areas, is certainly true. But, for example, integrated pest management is something that's been used in many areas very widely, and is really coming on very strong in many, many areas of the United States.

Mr. EMERSON. Dr. Carlson, you really rang some bells in your talk about problems with registration, and patent protection vis-a-vis FIFRA, which, I don't know if we're ever going to rewrite FIFRA—and you mentioned that biotechnology is so new in the developmental stage that patent rights and registration procedures haven't really settled.

So I'm assuming by your statement—correct me if I'm wrong—that you'd like to see FIFRA rewritten rather than just extended as we've been doing the last several occasions upon the expiration of the act, and see it include recognition of the advances that have been made in biotechnology; and to establish a framework within which what your industry needs can go forward in a systematic way.

Mr. CARLSON. I think it is true that FIFRA was written for chemicals. I think it is true that when the debate began about 8 years ago as to how do we regulate biologicals which will be pesticides, which are altered by the techniques of a combinant DNA. We erred on the side of calling them too much chemicals and not enough biologicals.

Within FIFRA, there are really two major areas. There's the chemical area and then there's the biorational, or section 158 areas. The biorationals really have much lower level scrutiny than chemicals because they are biologicals and because they have a track record of safety.

The problem that we have had is that recombinant DNA—that new tool—has shifted up the volume and been pushed from the biorational camp into the chemical camp looking at the toxicological and spread and feed effects, and focused issues on that.

I think that FIFRA as stands will work. It's not perfect, but it's OK. It's even good in certain situations.

What is inappropriate is the regulation of the product based on the tool to make it rather than what it actually is. Regulation based on product should be practiced rather than regulation based on process. We are coming to that point but it's very slow.

I would just mention a company in your home State—Monsanto—had a terrible time trying to do a field test 6 or 7 years ago now, with a recombinant microbe; in fact, the field test was never done. It was really because of an inadequate knowledge of what questions to ask and what are the important components to ask. That was regulation by tool, not by product.

We have coming to a place where that is less of a problem, but it's still is a problem. So I would not change FIFRA, because I don't know what the consequence would be. I would not rewrite the Constitution, because I don't know what the consequence would be. It's

not perfect but it's OK. But it's in the procedural ramifications that things go awry.

As you recall, we had a lot of activists, environmentalists, who were playing Rorschach tests with the issues; and those issues have not become—it's a lower volume in terms of scrutiny, in terms of concern. I would hope that the regulatory scene would also lower the requirements or at least look at the requirements and make the more compatible with the technology, given that history.

Mr. EMERSON. I am no longer on the Department Operations, Research, and Foreign Agriculture Subcommittee, which has jurisdiction over FIFRA. Have you testified before that subcommittee, or met with any of the leadership there?

Mr. CARLSON. No, no.

Mr. EMERSON. Mr. Chairman, I think it would be interesting—as a matter of fact, I think it would be very useful—if when the transcript of this hearing is prepared if we could refer Dr. Carlson's statement to the Department Operations, Research, and Foreign Agriculture Subcommittee, particularly to the attention of Chairman Brown and the ranking member, Mr. Roberts of Kansas, who labored daily with this very complex and technical subject.

And your statement here today, I thought was just dynamite, and I know they would be interested in it, and I hope we can refer it to them. I suggest you get in touch with them, and I'm going to tell them what you had to say here today to the extent that I can. I think they want to do business with you.

Mr. CARLSON. Terrific, terrific. I think this technology has got so much power that it's unfortunate to see it hobbled. As a practical matter, we are the only company using the combinant microbes in the environment as pesticides. We are the only ones going through this particular routine in a commercial perspective. And that was not true—5 years ago there were maybe six or seven companies. But the arduous nature and the capricious questioning really has limited the field.

I personally think in terms of stimulating agriculture, this technology has a lot to give.

Mr. EMERSON. Have you done any work with soybeans?

Mr. CARLSON. Yes.

Mr. EMERSON. Is there an answer to the cyst nematode problem?

Mr. CARLSON. The cyst nematode problem—I think there is an answer but it is not in the near future. The answer, of course, would be plant resistance or a resistance based on endophytes.

So if we had an endophyte that would go to soybeans—we have some candidates. And if we had a gene that would be active against nemotodes, that would be possible. There are certain candidate compounds that are produced by Merck, which when sprayed on is too expensive, and binds the soil particles. But if delivered in planta would be able to counteract that attack very nicely.

So there are some candidates on the horizon but they're not here and now. I think you're looking at a research program to define endophytes for soybean and to get those genes.

Mr. EMERSON. Have you any contact with the Delta Research Center of the University of Missouri by any chance?

Mr. CARLSON. No, I haven't, sir.

Mr. EMERSON. They have some very extensive cyst nematode research efforts under way involving some Federal research dollars. I think that research center may be the leading research center in the country doing work on the cyst nematode problem.

I'd like to get you in communication with them as well.

Mr. CARLSON. Excellent. I think that it's fair to say the cyst nematode 3 has been a bane for many, many years, and it's an opportunity.

Mr. EMERSON. They keep developing new strains of soybeans that are more resistant than the old strains but then after a year or two they fall back into the same old ruts and get overtaken by the nematodes again.

Mr. CARLSON. That's right.

Mr. EMERSON. Mr. Chairman, the soybean cyst nematode problem——

Mr. HALL. I'm glad that you raised this issue. [Laughter.]

Mr. EMERSON [continuing.] It's a $2 billion problem. Agricultural economists estimate that these little cysts attach themselves to the roots of soybean plants and drain their productivity. And agricultural experts tell us that it costs our producers about $2 billion a year in productivity. When nematodes are attached to the roots of the plants, the plants just don't produce as well.

That's the reason that we've had some research money directed to try to find a cure for this problem.

And I really want you to be in touch with the Department Operations Subcommittee and the University of Missouri Delta Research Center. And I'd be glad to get together with you after this hearing and let's plot a little strategy about how we go about that.

Thank you both very much.

Mr. CARLSON. Thank you, sir.

Mr. HALL. I'm glad that Mr. Emerson is on this committee; he's going to need to interpret for the committee the last 10 minutes or more—especially to me. [Laughter.]

Thank you for your overall testimony and, again, the testimony was great. Please continue to work with us, inform us of what you're doing, and we will keep in touch with you.

We thank all of you again for a very good hearing.

The hearing is adjourned.

[Whereupon, at 4:25 p.m., the committee was adjourned.]

[Material submitted for inclusion in the record follows:]

Prepared Statement of Hon. Byron L. Dorgan, a Representative in Congress From the State of North Dakota

I regret being detained in a Ways and Means Committee mark-up during this hearing. I did want to participate in this discussion of strategies for ending global hunger and poverty on World Food Day.

At the same time that western nations are experiencing food overproduction and a grain price collapse, nearly a billion people in the developing world are going hungry. It is clearly a problem of access to world food supplies. The hungry poor cannot raise or buy enough food. Food aid may not arrive because of inadequate delivery systems.

Expanding populations in developing countries have resulted in increasing pressure on soil and water resources. We have already begun to witness concomitant declines in productivity in some areas, e.g., sub-Saharan Africa.

Famine relief efforts, while laudable, are merely a bandaid. A sustainable approach to reducing hunger requires getting at the root of the problem. Three-fourths of the world's poorest people live in rural areas and depend on agrarian economies to survive. Any serious effort to reduce poverty or eliminate hunger must emphasize rural development.

A program such as that suggested today, which emphasizes the development and transfer of agricultural technologies, building rural infrastructure such as paved roads, and education, makes good sense. It is the approach that we used to develop the U.S.

Stable crop yields and increased income and rural employment opportunities will not only improve poor people's access to food but expand rural economies. Experience has shown that their demand for food will also rise, creating a new market for our products.

We need to explore some of the suggestions given today. More creative uses of food aid which encourage parents to leave their children in school have several obvious benefits. Commercial debt writedown in least developed countries would help to reverse their negative cash-flow and jump start development efforts.

Lately, development efforts have emphasized putting the best macropolicies in place. Perhaps it is now time to reorient our aid programs. The U.S. has the finest agricultural research and extension system in the world, and the best technical international development network. We need to make better use of them.

Prepared Statement of Hon. Bill Emerson, a Representative in Congress From the State of Missouri

Thank you Mr. Chairman, I would first like to extend a warm welcome to our witnesses here today. I very much look forward to hearing their testimony today as this is a subject of particular interest to me. As a conferee on the 1990 farm bill, I have looked forward to working with other conferees to make this important piece of legislation one that will shape the future of agriculture for not only the next five years, but for the rest of the decade and beyond. As vice-chairman of the Domestic Marketing, Consumer Relations, and Nutrition subcommittee we have specific jurisdiction over the food and nutrition portions of the legislation-- something that is of interest to all of us here today.

Here in the United States we are much more fortunate than some other areas of the world. Many countries in Asia, Latin America, and especially Africa are experiencing shortages that are devastating their economies and starving their people. As our nation and the world become more aware of our environmental needs, food policies and future research become increasingly important to continue to promote responsible and sound conservation and environmental efforts. As you well know, science holds the key to unlocking the answers to many of sustainable agriculture's difficult questions. The task before researchers is vast and complicated. Before significant adoption of sustainable

agriculture can occur, new ways of thinking must be tested. Likewise, reliable information must be made available in order to make rational decisions applicable to mainstream agriculture. I look forward to hearing from our witness on ways in which we can continue to gain a knowledgeable comprehension about feeding the world's growing population and at the same time preserving our environment for future generations.

PREPARED STATEMENT OF LAURA HENDERSON AND JOHN W. MELLOR, INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE, WASHINGTON, DC

ENDING HUNGER: AN IMPLEMENTABLE PROGRAM FOR SELF-RELIANT GROWTH*

Mr. Chairman, thank you very much for inviting me to address this committee on a topic of great concern to us all--that of ending world hunger. We now have the knowledge and ability to radically reduce the scourge of poverty and hunger throughout the world, through environmentally sound rural development and broad-based growth. Growth is the ultimate key, for without it the well-being of the poverty stricken masses cannot improve in a sustainable manner. This growth can be facilitated through well integrated improvements in *three key pillars of development*--productivity enhancing technology, infrastructure and education. The driving thrust of our presentation is the need for a *major reallocation of resources* towards these appropriate development processes. In the context of such growth, attention to the health of children and to public health generally will not only pay higher dividends when coupled with growth, but the cost of providing and sustaining health improvements will decline over time.

DEFINITION OF POVERTY IN TERMS OF HUNGER

We begin by noting the close link between poverty and hunger. Absolute poverty is defined at the International Food Policy Research Institute (IFPRI) as the inability of households and individuals to meet basic levels of food consumption for an active and healthy life. Poverty is the condition in which food consumption falls below a certain threshold

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* Paper to be presented to the hearing entitled, *"World Food Day...Food for the Future,"* at the Select Committee on Hunger of the U.S. House of Representatives, Washington, DC (October 16, 1990).

below which an active and healthy life is not assured. The poor must and will spend some of their limited income on items other than food and so we define a "poverty line income" as one which reflects those larger expenditure patterns in the context of the basic food requirement. The poverty line (threshold) is defined by FAO by calorie consumption at 80 percent of recommended consumption for an active and healthy life. Food consumption may fall below the poverty line when people are unable to acquire food, either through purchase or production. The goal of providing the poor with increased job opportunities is to enable them to have an income which ensures adequate food intake in addition to other vital necessities.

Low and uncertain incomes coupled with completely inadequate health services are the roots of the food and nutrition problem. Slow growth, absence of productivity-enhancing technology, and increased land scarcity in the face of rapid population growth are the key factors leading to low labor productivity, which results in low incomes. Dealing with these problems of poverty and hunger is an extraordinarily complex matter, but given the progress made by many developing countries over the past fifteen years, we can now provide focus and set priorities by concentrating on a few key elements.

WHO ARE THE HUNGRY?

The world's hungry are by no means a homogenous group. As their numbers indicate, the group is extremely diverse. However, five groups are particularly vulnerable to poverty: (1) *deficit farmers and landless laborers* (by far the most numerous) whose income depends on primarily on employment, wages and food prices; (2) *subsistence farmers*, whose income

depends primarily on the productivity of their land; (3) *small surplus farmers*, whose income is dependent on productivity, prices of crops (particularly export crops which have highly volatile prices) they sell and of the food they purchase; and (4) *urban poor*, whose income depends on employment opportunities, wages, and the prices of food;[1] and (5) *women and children, the elderly and the sick* who are often unable to earn incomes adequate to provide for even their most basic food needs. In the vast majority of cases, the poor are net purchasers of food, making high food prices very painful, and underscoring the urgency of helping to create off-farm employment. Food availability is not synonymous with food accessibility. The latter involves many more factors than the former, most importantly, food accessibility requires the income to enable the needy to purchase adequate food. As we will emphasize later, food production, or agricultural production more broadly, is critical both directly and indirectly to providing the requisite employment and purchasing power.

NUMBERS OF HUNGRY POOR

The World Bank, using a less restrictive definition than IFPRI, has estimated that as of 1985, the number of people living under the poverty line of $370 per year in the developing world was 1.12 billion people. (The poverty line in 1985 purchasing power parity dollars is $370 per capita; incomes per capita of $275 is considered extremely poor--see

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[1] Paul Streeten. 1987. *What price food: Agricultural price policies in developing countries*. New York: St. Martin's Press, pp. 60-61.

Table 2) This staggering figure constitutes approximately one-third of the entire population of the developing world, making it clear that redistribution alone is not sufficient. The hungry poor must be lifted out of poverty by growth. An IFPRI estimate places the number of hungry poor at 700 million people for 1990 (Table 1) Estimates of the number of hungry poor clearly depend on where the poverty line is drawn. The 700 million is an extremely conservative estimate, which uses a lower poverty standard than does the World Bank in arriving at its equally valuable estimate of one billion.

WHERE ARE THE POOR?

Food related policies, programs and research must be reoriented to emphasize the needs and aspirations of the rural poor. Although the numbers of urban poor are continuing to increase, according to IFPRI analyses, *over three quarters of the world's poor currently live in rural areas.* (Table 1) In Africa, approximately 90 percent of the poor are rural, in South Asia 80 percent and in Latin America about 60 percent. A major effort to end hunger must focus on South Asia, Africa and China, where 80 percent of the world's hungry poor live (see Table 1 and 2). Roughly half of the developing world's poor are located in South Asia alone, with some 50 percent of them living in extreme poverty. Sub-Saharan Africa's poverty rate is almost as high as that of South Asia resulting in 180 million hungry in that continent (with a total number of hungry poor which is 35-40 percent as large as the number in South Asia). Another 210 million of the hungry poor are inhabitants of mainland China. Of the remaining, approximately one-third live in Latin America and the

Table 1--Rural-urban distribution of poverty and the estimated number of people living in areas of high potential, figures projected to 1990*

	Total	Urban	Rural	Agricultural Potential	
				High	Low
	..... (in millions)				
Africa	137	14	123	61 (50)	62
S. Asia	350	70	280	140 (50)	140
E. Asia	31	5	26	6 (25)	20
L. America	72	29	43	11 (25)	32
Near East	34	10	24	11 (35)	23
China	76	--	76	26 (33)	50
Total	700	188	548	255	327

Source: John W. Mellor. 1990. "Ending Hunger," in *The World Food Crisis: Food Security in a Comparable Perspective*, edited by J.I. Hans Bakker. Toronto: Canadian Scholars' Press, Inc.

* The distribution by rural and urban classification is based on a survey of country poverty studies. There are indications that there is a little malnutrition in urban areas of China, but there is a paucity of definite data, thus poverty in China is grouped under rural poverty. All numbers are tentative and should be seen as merely indicative.

Table 2--Poverty in the developing countries, 1985

Region	Extremely Poor			Poor		
	Number (millions)	Headcount Index (%)	Poverty Gap	Number (millions)	Headcount Index (%)	Poverty Gap
S-S Africa	120	30	4	180	47	11
East Asia	120	9	0.4	280	20	1
China	80	8	1	210	20	3
South Asia	300	29	3	520	51	10
India	250	33	4	420	55	12
E. Europe	3	4	0.2	6	8	0.5
M. East & N. Africa	40	21	1	60	31	2
L. America Caribbean	50	12	1	70	19	1
All dev'g countries	633	18	1	1,116	3	3

Source: World Bank, World Development Report, 1990, p. 29.

Caribbean, one-third in East Asia exclusive of China, and one-third in the rest of the world--the Middle East, North Africa, and Eastern Europe. It should be noted that given South Asia's projected decline in poverty and Sub-Saharan Africa's projected increase in poverty, the later may well have a larger absolute number of hungry poor by the year 2000, suggesting a need for increased attention over the next decade.

IFPRI is currently conducting research to expand upon FAO's study on agro-ecological zones and population density. To date, data suggests that within the least developed countries, the poor are concentrated on lands with the relatively higher food production potential. Poverty levels are generally lower in the areas producing the perennial tropical export crops. According to the Center for Monitoring the Indian Economy, as of 1982 about 50 percent of the rural poor in India lived on the Eastern Gangetic Plain on only 22 percent of India's total land area. If we add Bangladesh's poor population, living on its deltaic area, we have a high concentration of the poor in a fertile, agriculturally promising area which is potentially highly responsive to new technology. While the percentage of the population that is very poor tends to be somewhat lower in areas with high agricultural potential than in marginal lands, the absolute numbers of poor are quite large due to high population densities in the fertile lands.

HOW TO ELIMINATE POVERTY AND HUNGER

We want to underline the pivotal role of growth in reducing absolute poverty. Growth is defined as the process of sustained increases in per capita real income. Increases in per capita real income will lift the

poor out of their poverty if the growth occurs with increasing equity and stability in any given country. An employment expanding rural growth strategy in which agricultural growth figures prominently is central to poverty alleviation in low income countries. The agricultural focus stems from its dominant position, both directly and indirectly through demand links with other sectors, *vis-a-vis* employment in developing countries. Direct industrialization strategies are more capital intensive and thus have less capability to generate employment.

As growth is directly related to diminishing poverty, so growth should be located in the areas where most of the poor live. Furthermore, growth must raise people out of hunger by increasing their productive capacity. Efforts toward the abolition of hunger should primarily be rural-based since this is where the majority of the poor, hungry people live. Without a marked increase in both income and employment opportunities in rural areas, sustainable overall development will not be possible. Vigorous rural development will also lessen job competition in the large cities, reducing rural-urban migration, and thus help reduce the numbers of urban poor. In the past, donors and recipients of foreign aid alike have emphasized redistribution as the key to poverty alleviation rather than emphasizing growth. It is time to rectify this error.

Growth is capable of major reductions in absolute poverty, as evidence from numerous countries reveals. Incomes and overall welfare can steadily improve only if economic growth is significantly higher than population growth. The world's poorest countries are suffering from ever increasing poverty, suggesting that a resource constraint relative to population growth is a leading cause of the failure to reduce poverty.

Africa and some parts of South Asia have experienced the most dramatic increases in poverty and hunger. Recent evidence from Latin America clearly demonstrates how easy it is to go backwards in terms of poverty reduction if growth is not sustained.

Five Indian states (Andhra Pradesh, Gujarat, Haryana, Kerala and Punjab) experienced over a 50 percent fall in their proportion of rural poor in absolute poverty in the twenty year period between 1964/65 and 1983 (see Table 3). Both of these years followed very good agricultural years, and the decrease in the proportion of the rural population in absolute poverty was approximately 29 percent for India as a whole. For a country as poor as India, this was an remarkable accomplishment. Note that four of the five states with greater than a 50 percent decline in poverty were top ranking states in agricultural growth. The state of Kerala had heavy migration to the Middle East. These are also states with a higher concentration of surfaced roads and per capita power consumption in agriculture.[2]

Agricultural growth increases incomes in the nonfarm rural sector as well as in the farm sector, and a broad based transition to an increased industrial/service economy occurs. It does this as rising farm incomes finance a large growth in rural nonfarm production of goods and services.

The case for agricultural growth in the middle-income countries has been empirically demonstrated through studies of Thailand and Brazil. Thailand's experience demonstrates that an emphasis on expanding and developing the agricultural sector has led to a steady decline in poverty

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[2] Rajul Pandya-Lorch. 1989. *Poverty Review of India*. Washington DC: International Food Policy Research Institute.

Table 3--Agricultural growth rates and change in the incidence of rural poverty in India

States	Production Growth Rates		Incidence of Poverty				% Change 1964-65 1982-83
	Foodgrains 1964-83	Agriculture	1964-65	1972-73	1977-78	1982-83	
Success states	3.93	3.62					
Andhra Pradesh	2.91	3.31	41.2	46.7	30.6	19.4	-52.91
Gujarat	3.76	3.92	51.0	43.3	31.8	15.9	-68.82
Haryana	5.12	3.31	24.7	16.5	20.1	12.1	-51.01
Kerala	0.71	N.A	61.6	55.5	41.8	27.8	-54.87
Punjab	7.15	3.92	26.0	16.2	10.9	8.7	-66.54
Miserable states	1.42	1.29					
Bihar	1.45	0.49	53.0	60.3	55.4	56.4	6.42
Madhya Pradesh	2.36	1.65	40.7	55.3	51.8	36.7	-9.83
Orissa	1.17	2.28	60.9	67.4	61.6	53.6	-11.99
Tam il Nadu	0.71	1.12	57.8	49.8	48.8	44.5	-23.01
West Bengal	1.41	0.90	65.7	66.5	62.3	54.7	-16.74
Middle states	2.96	3.4					
Assam	1.64	N.A	20.1	38.5	38.3	23.1	14.93
Karnataka	2.79	2.44	54.4	44.1	42.5	31.3	-42.46
Maharashtra	4.00	5.59	60.5	62.6	54.1	34.7	-42.64
Rajasthan	3.08	2.47	30.0	36.4	24.3	21.4	-25.33
Uttar Pradesh	3.35	3.10	53.2	43.8	38.9	37.0	-30.45
All India weighted Ave	2.99	2.37	50.44	50.36	44.2	35.9	-28.83
Coefficient of variation weighted			22.4	23.1	28.2	36.4	

Source:

1. The levels of rural poverty data are from D. Mahendra Dev, "Regional disparities in agricultural labor productivities and rural poverty in India," The Indian Economic Review, Vol. 23 (No. 2, July-Dec 1988).

2. Foodgrain production growth rates calculated from data on area and production of principal crops in India, various years, Government of India, Ministry of Agriculture, Directorate of Economics and Statistics.

3. Agriculture production growth rates are from Raj Krishna, "Agri. Regional dimensions of Indian agriculture," in the Indian Economy: Recent Development and Future Prospects, edited by Robert E.B. Lucas and Gustav F. Papanek, 1988.

Notes: The 15 states are divided according to the following definitions:

Success states: Poverty incidence in 1961 less than 20 percent and/or more than 50 percent decline in poverty incidence between 1964-65 and 1983.

Miserable states: Poverty incidence in 1961 more than 40 percent and/or less than 20 percent decline in poverty incidence between 1964-65 and 1983.

Middle states: Poverty incidence in 1961 less than 40 percent and/or 20 percent to 50 percent decline in poverty incidence between 1964-65 and 1983.

Brazil's experience shows that agricultural employment creation is not essential to reducing poverty, and that rural sector growth is important. Malaysia and Indonesia both provide evidence that concerted public sector efforts in education and infrastructural development, in addition to an agricultural and rural focus, can accelerate the rate at which agricultural growth may be translated into reduced poverty. In all four of the aforementioned countries, it took less than a generation to cut rural poverty in half. That is an impressive record indeed!

Several important conclusions can be drawn from the poverty reduction experiences of India, Brazil, Thailand, Malaysia and Indonesia: (1) agricultural growth stimulates marked growth in the nonagricultural sector; (2) rural technology, infrastructure and education all play a vital role in promoting agricultural growth; and (3) economic growth led by agriculture results in a rapid fall in absolute poverty.

Empirical evidence demonstrates that dramatic decreases in poverty occur in periods of rapid growth in conjunction with employment generation and policy strategies to reinforce this type of growth. At a minimum, poverty relief requires that food supplies rise, that employment growth rise much faster than population growth so as to reduce both unemployment and underemployment, and that basic services be made available to the rural areas as well as the urban areas.

ACTION PROGRAM FOR RADICALLY REDUCING HUNGER

The following propositions form the basis of an innovative, implementable action program, centered on food and rural development, that can bring about self-reliant growth that radically reduces poverty and hunger.

(1) ***A massive reallocation of resources towards three pillars of rural development*** (technology, infrastructure and education) is essential for radically reducing hunger. *First*, developing countries must develop modern research institutions to produce a steady stream of productivity increasing agricultural innovations as well as the other institutions needed to rapidly spread those innovations. *Second*, rural roads and complementary infrastructure must be built and integrated into the larger community to provide the regional networks essential to trade and sustainable development. *Finally*, the world's poor must be integrated into the larger world and empowered through dramatically increased investment to provide increased access to education and literacy training. ***These three pillars are expanded upon in the following pages.***

(2) ***Ensuring food security*** requires at minimum: (a) the formulation of agricultural policies in both the developed and developing world that take the world's hungry and malnourished into account, (b) a commitment on the part of the developing countries themselves to achieve adequacy and stability of both food supplies and income amongst all classes, and (c) the improvement and rehabilitation of international forms of food security such as the IMF cereal facility.

(3) ***The long term effectiveness of UNICEF's focus on children and the World Health Organization's attacks on ill health*** can be dramatically increased, and in turn justify much larger expenditure, precisely because they'll be more effective if accompanied by broad based, sustainable growth and increased incomes.

(4) ***Poverty alleviation measures must be environmentally sound.*** Environmental protection must accompany a reduction in poverty, and help ensure the permanence and sustainability of the reduction.

(5) ***A large portion of the worst poverty can be eliminated in rural areas with high agricultural potential.*** It follows that natural resources and foreign aid alike need to be refocused on modern agricultural technologies, infrastructure, and education in such areas, particularly in the poorest countries. There must be a particular emphasis on high potential areas, and as we begin to succeed in reducing poverty in those areas, we can shift more resources to areas of low-agricultural potential. ***In areas in which agricultural rates of return will not be as high, infrastructure and education can help move people and resources to their most productive uses.*** Such lower potential areas are found throughout the developing world, in both the poorest countries and in pockets of poverty in the middle income countries. Since the necessary investments do not have as high a rate of return, foreign assistance to such areas must be specifically encouraged, but not at the expense of the high potential areas in low income countries.

(6) ***Multilateral, bilateral and nongovernmental agencies*** urgently need to improve coordination among themselves and with concerned government agencies in the field.

to designing and implementing projects that stimulate the process of rural development and work towards reducing both hunger and malnutrition.

THREE KEY PILLARS OF DEVELOPMENT: TECHNOLOGY, INFRASTRUCTURE, AND EDUCATION

I. TECHNOLOGY

Our plan emphasizes efficiency enhancing innovations for increased productivity of agricultural products, principally food crops, but eventually animal feeds and cash crops as well. Technology should be designed to augment the constrained factor in any given region--whether land, labor, or capital. Care should also be given to assuring that the technology is appropriate for the given region and culture. Cultivation of high yielding seed varieties, improved extension, credit and research facilities, and where appropriate, increased fertilizer and irrigation are all vital elements of technological development.

An institutional structure should be created to assist with agricultural research designed to broaden the range of crops that can be grown under given conditions, to reduce the costs of production via more efficient input utilization, to reduce the risks inherent in the climate and other natural conditions in order to stabilize production, and importantly, to contribute to both the provision of better foods and to employment possibilities.

Developing country extension services have tremendous untapped potential to serve as a vital mechanism for generating feedback from the farmer and regularly channeling it to the appropriate agricultural research systems. Agricultural technologies can only be developed in an

appropriate manner if pertinent information on the diverse experiences of small farmers throughout the world reaches research systems on an ongoing basis.

The transfer of new technology for agricultural development can be successful in the long run only if accompanied by the promotion of a nationally integrated formal rural financial market with sustained government support. Agricultural credit policies aimed at facilitating rural growth with equity, enlarging the economies of scale of formal rural financial institutions and integrating rural financial markets are absolutely essential to any global plan to radically reduce hunger and poverty.

II. INFRASTRUCTURE

Empirical evidence from a variety of IFPRI studies demonstrates that the positive impact of infrastructures (roads, dams, transportation facilities, irrigation systems, etc.) on the production and distribution of goods and services is immense and is particularly important to hunger reduction. Integrated all-weather roads enable and encourage agricultural extension agents, health care practitioners and teachers to provide services in isolated areas previously out of their reach. The physical infrastructure currently found in the developing world does not approach the requirements for optimal social and economic integration. Poor countries underinvest in infrastructure because of the large resource requirements and some uncertainty about the size of the economic and political payoff. During the mid-eighties, 75 percent of the total global population accounted for 13 percent of rail freight and 10 percent of

paved highways. Furthermore, the vast majority of infrastructural services were found in cities, not in rural areas. Asia stands out as the only part of the developing world since 1978, where there has been an increase in the central government expenditure in transport and communications infrastructure, as a percentage of total expenditure. This however has not been sustained and has slightly declined over the last five years. (see Table 4)

Thus, while the importance of rural infrastructure to poverty reduction has become more clear, the priority and resources given to this area have lessened.

According to several IFPRI studies, the key rationales behind the argument that the development of rural infrastructure plays a strategic role in agriculture and overall development are as follows:

Rural infrastructure:

* reduces trading costs and increases competitiveness in markets;
* accelerates specialization and commercialization processes;
* expands demand for non-agricultural products through both farm and nonfarm cash income increases, and makes those products more accessible to the countryside;
* accelerates the diffusion of technology and increases the efficiency of resource use, including the spread of small scale irrigation devices, new crop alternatives, market information and fertilizer.[3]

Many large-scale infrastructure projects have been poorly managed, with little or no attention given to maintenance. Aid should increasingly be directed towards labor-intensive small to medium scale infrastructure

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[3] Ahmed and Donovan. 1989. *The Impacts of Rural Infrastructure on Production in Developing Areas*, IFPRI.

Table 4--Central government expenditure on transport and communications as a percentage of total expenditure (simple averages with standard deviation in parentheses)

	1988	1983	1978
Developed countries	5.33 (2.63)	5.90 (3.00)	6.91 (2.86)
Less Developed Countries			
Africa	7.13 (4.25)	8.05 (5.38)	11.22 (6.20)
Asia	11.03 (6.33)	11.51 (7.15)	10.30 (5.26)
Western Hemisphere	7.43 (3.85)	8.35 (4.82)	8.81 (2.87)

Source: IMF, *Government Statistics Yearbook 1988 and 1978.*

Note: Only in Asia has there been an increase in the transport and communications area since 1978, although the most recent years show a slight decline.

projects in rural areas, where opportunities to organize labor abound. To succeed, this requires decentralization of government which is consistent with a desirable emphasis on democratization.

Furthermore, the refurbishing, maintenance and management of existing infrastructure should be given higher priority than it currently receives. See Figure 1, which outlines the World Bank's lending commitments, graphically demonstrating the dramatic fall over the past thirty years in their funding for infrastructure. In reviewing the infrastructure tables, please note that while we are emphasizing the importance of increased expenditure on rural infrastructure, the attached Table 4 and Figure 1 provide numbers for rural and urban infrastructure combined.

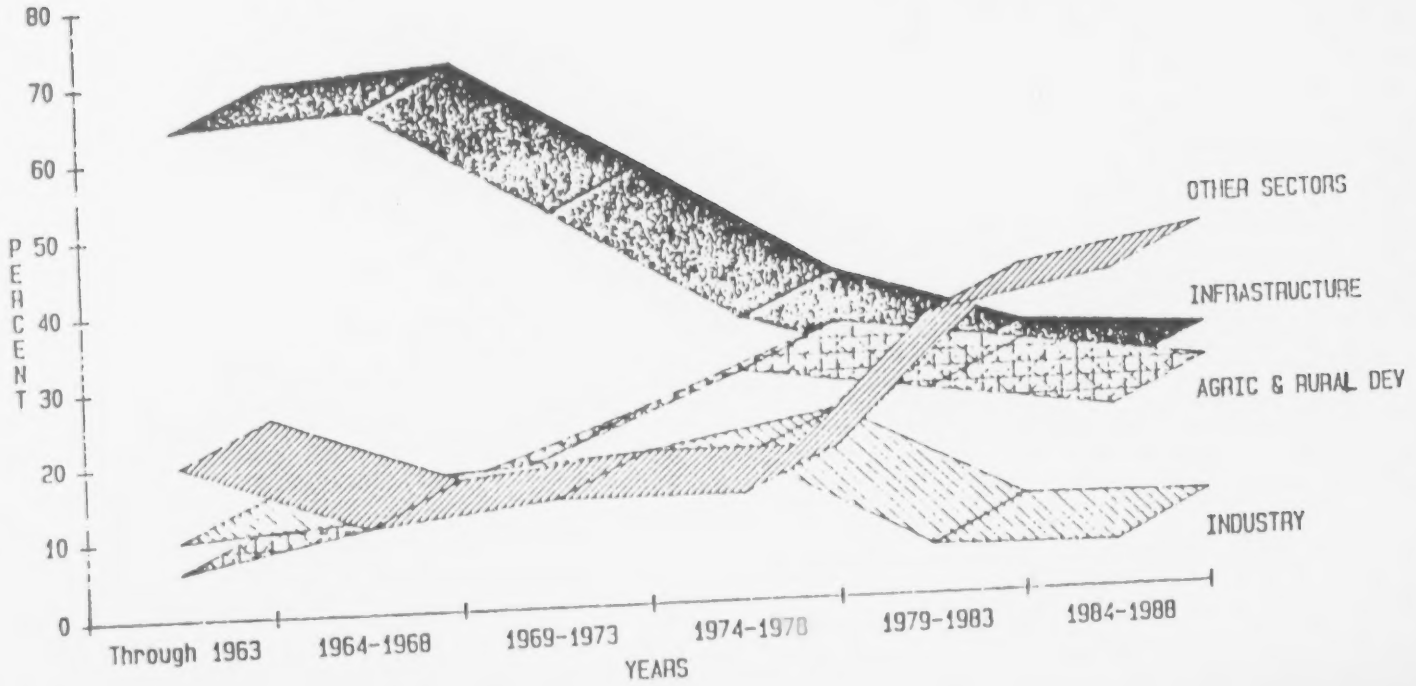
Rather than contributing to environmental degradation, well planned and managed infrastructure projects can serve as a powerful weapon for environmental preservation. Flooding can be reduced with adequate drainage provisions in roads, and local governments can focus attention on reforestation and the protection of community property in the planning and implementation of projects. The positive ripple effects from income generating infrastructure projects are in fact immeasurable.

International Food Policy Research Institute studies show that in areas with all-weather roads, farmers use twice as much fertilizer per acre, nonagricultural employment is 30 percent higher, agricultural employment is substantially higher and poverty is 40 percent lower than in areas without usable roads. Poverty reduction efforts are clearly aided by the building of adequate infrastructure.

Figure 1

WORLD BANK LENDING COMMITMENTS

Simple Average Percent of Total



Source: World Bank Annual Report, 1972-1988

Historically, food aid and financial aid have been kept relatively separated. Food aid has been seen and used more as a relief mechanism to provide food for the hungry poor, or for dumping first-world food surpluses, than as a positive and constructive developmental input. Food aid can be much more effectively used as an essential input for well-managed, appropriate and sustainable food-for-work projects to build desperately needed roads and other infrastructure.

III. EDUCATION

Dynamic rural economies throughout the developing world are generating greater opportunities for educated labor. By contrast, urban labor demand is not keeping pace with the increasing supply of educated school graduates. This dichotomy between the increasing opportunities in rural areas for the educated and the decreasing employment possibilities in the urban areas demonstrates that a higher percentage of foreign aid for education and training should be directed towards rural areas. In most cases, the agricultural production and consequent profits of farmers can be increased if their basic education and their marketing, technical and managerial skills are enhanced.

According to IFPRI studies, returns to education and human capital accumulation in rural areas may take three different forms: (1) greater employment opportunities and earning in non-agricultural rural employment; (2) changes in rural household behavior; and (3) increases in earnings and productivity in agriculture. In terms of household behavior, increased levels of education are often correlated with higher nutritional levels and reduced fertility and infant mortality. As educational levels

increase, the acceptance of modern technologies widens. Improved education is viewed as a necessary precondition for increased effectiveness in the use of agricultural research and extension agents. All of these forces are critical to the types of growth that drastically reduce hunger.

THE U.S. ROLE IN THE WAR ON HUNGER

The Fiscal Year 1990 foreign aid appropriations bill states "The Congress finds that reduction of poverty on a global basis is a fundamental goal of the United States foreign assistance." Earlier this year, the Appropriations Committee expressed disappointment to AID for showing "insufficient concern with poverty issues".

U.S. foreign assistance could more effectively attack poverty and hunger through designing and implementing projects with a rural development orientation. USAID's new strategy stresses democratization and privatization. A rural orientation, which emphasizes decentralization and democratization, as well as rigorous growth of the private sector is essential to the larger program and to the plan that we are putting forward. Dynamic, profitable small and medium size private enterprises are a vital complement to our agriculture-led growth strategy.

In order to encourage the sustainability of US-funded projects--and in so doing contribute to the reduction of poverty and hunger--we urgently need to improve the cooperation and communication between recipient and donor. Few would question the importance of a given development project being wanted as well as needed by the recipients, however many donors remain either unaware or unconcerned with teaching recipients how to

maintain and manage projects ranging from water pumps to irrigation machinery. Furthermore, our assault on hunger and poverty can only succeed if we do a better job of monitoring what is and isn't working so that we can capitalize on our successes and minimize our failures.

The United States government should encourage international institutions such as the World Bank the African and Inter-American Development Banks, and the FAO to follow similar rural-development-oriented strategies. Furthermore, we should look at our own grain storage policies from a market development point of view and should urge the Treasury Department's support in reviving the now moribund IMF Cereal Facility.

In the ultimate analysis, the alleviation of hunger and the expansion of employment opportunities is inextricably tied to long-term, self-reliant growth. Targeted programs for the well being of children (such as UNICEF's and WHO's) will help to create the environment within which we can have successful programs of food security and improved health and nutrition. Furthermore, by improving infrastructure, access to education, and appropriate agricultural technology, we can create a fertile environment for the poor to make optimal use of the growth-based income generating opportunities. There is tremendous scope for food aid in the building of infrastructure and the expansion of educational opportunities. The U.S. must be a reliable supplier of food, helping to provide stability in the global prices of food to help ensure food security for the needy. Improved infrastructure in developing countries results in both increased interaction and trade with the outside world and in enhanced informal education processes that contribute to human capital

development. In the final analysis, our assault on world hunger can only succeed if fueled by a major reallocation of foreign aid.

PREPARED STATEMENT OF PAUL FAETH, ASSOCIATE, ECONOMICS RESEARCH PROGRAM, WORLD RESOURCES INSTITUTE

Working Toward a Sustainable Agriculture

I. An Operational Definition of Sustainable Agriculture

In recent years, a number of researchers and organizations have struggled to develop definitions of "sustainable agriculture." Almost all of these definitions encompass elements of productivity maintenance, farm profitability, and reduction of environmental impacts. These definitions have been qualitative, not quantitative. The notion of agricultural sustainability has therefore been of conceptual, but not operational, use to policymakers and researchers attempting to determine the effects

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[1] The World Resources Institute (WRI) is a private, not-for-profit research and policy institute aiming to generate accurate information about global resources and environmental conditions, analyze emerging issues, and develop creative yet workable policy responses.

[2] The opinions expressed here are those of the author and do not necessarily represent positions held by WRI.

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of various policies and technologies on agricultural resources.

Sustainability means that economic activity should meet the needs and aspirations of the present without sacrificing those of the future; the resources required to provide the needs of the future must not be depleted to satisfy today's consumption. The fundamental definition of income found in economic and accounting textbooks encompasses this notion of sustainability. Income is defined as the maximum amount that can be consumed this year without reducing potential consumption in future years. "Living off your capital," is ultimately unsustainable. Economic assets must be conserved and increased in order to provide for the increasing needs of the future.

Current income accounting systems for both nations and businesses apply a very narrow definition of a productive asset, including only man-made physical plant and equipment. We recognize that capital assets, such as barns and tractors, wear out, and that we must maintain and replace these in order to sustain production. Unfortunately, we do not recognize natural resources as productive assets in the same way. As a tractor depreciates we make an allowance for that by subtracting the economic value of the depreciation from current income. But, if soil is degraded, water polluted, or wildlife habitat destroyed, we ignore the loss. Yet, the degradation or depletion of these resources is a certain economic loss to both farmers and society.

This false dichotomy between natural and man-made assets has led the United States, and many other countries, to implement agricultural policies that discourage the adoption of sustainable agricultural practices and to develop agricultural technologies with little regard for their impact upon the resource base.

WRI is currently investigating the impact of agricultural policy on the adoption of sustainable agricultural practices. We have undertaken case studies in the United States, India, the Philippines, Australia and Chile. The accounting framework we are applying in these case studies allows us to treat natural resources as depreciable assets. This framework provides more accurate estimates of the economic performance of agricultural technologies. Most important, the framework allows us to evaluate alternative policies to determine their impact upon the relative economics of sustainable practices, the key to adoption by farmers.

We are about to publish our results from two US case studies, in Pennsylvania and Nebraska. These two case studies represent extremes on the spectrum of environmental costs in the United States. The United States Department of Agriculture (USDA) has estimated the off-farm damages caused by agriculturally-related soil erosion to navigation, fishing, water treatment, recreation, and other water-quality related activities. In the Northeast, the damage caused by one ton of eroded soil amounts to $8.16, the

highest in the nation. By contrast, in Nebraska these damages are the lowest, amounting to only $0.66 per ton. Similarly, the soils of Nebraska are more robust, losing productivity slower than the more fragile soils of Pennsylvania.

When the resource costs of agricultural production in these two areas are accounted for, the effect of policy on agricultural sustainability can be seen. In the United States, it is clear that our current system of supporting farm income through the commodity programs discourages the adoption of resource-conserving practices. Base acreage constraints and program crop definitions put resource-conserving crop rotations at a financial disadvantage, in spite of the fact that farming practices which reduce soil erosion and improve soil productivity can provide a significant net economic gain to society. Crop production using conventional practices however, can mean a large net economic loss to society, even though current policy may make these practices most profitable to farmers through taxpayer subsidies.

If the distorting effects of current policy were removed, as would happen under a policy of multi-lateral free trade, net farm income and net economic value could increase considerably for both conventional and alternative practices. In areas with high resource costs, such as Pennsylvania, resource-conserving practices would become more profitable options, greatly encouraging their adoption. In low-resource cost areas such as Nebraska, while farmers would

not necessarily change practices, they would enjoy the benefit of higher crop prices which would result from world-wide free trade. As a result, society would have to bear fewer negative environmental impacts from agriculture, government expenditures for income support could be dramatically reduced, and farm income could be maintained or improved. Everyone wins.

In two case studies our research is focussing on irrigated production systems for wheat, rice and maize, in India, and rice in the Philippines. A number of significant environmental problems are present in these areas. In India, groundwater is being depleted, pesticides have become ineffective, and soils are becoming less productive. In the Philippines, surface water pollution by pesticides has become a serious problem as well as degraded soil productivity. In both places, which have been long-time beneficiaries of Green Revolution technologies, advances in productivity have slowed or halted. In order for the Philippines to maintain self-sufficiency in rice, they must increase their average yields from four, to five tons per hectare per year by the end on the century. It is likely that this goal will not be achieved.

The analysis for these case studies will contrast the current policies, characterized by low crop prices and subsidized fertilizers, pesticides and energy, with a set of reduced input subsidies for purchased inputs and higher crop prices. We expect

that these alternative policies would raise the returns to farming systems that use purchased inputs more efficiently and make more intensive use of non-purchased inputs, including labor.

In contrast to the Philippines and India, Chile's agricultural policy setting is characterized by few distortions in input and output prices. In that case we are examining systems of grape production, where over the last few years, it has been estimated that as many as half the farmers have freely moved to organic production practices. We expect to find that the absence of distortions has encouraged the use of practices that reduce environmental costs.

II. The Need for Agricultural Sustainability

We are facing a critical time in our history. Population growth and environmental quality are moving in opposite directions. The demands of our race are continually increasing, while our natural capital is decreasing, and at an expanding rate. To avoid catastrophe, natural resource use must be put on a sustainable footing.

In agriculture, which is so fundamentally dependent upon natural resources, sustainability is essential for future productivity. Unfortunately, in many areas of the world, past production practices have been anything but sustainable, and

resources have been severely damaged. Severe soil erosion and salinization are frequent problems. Groundwater depletion and ground- and surfacewater contamination are increasingly common phenomena.

The International Rice Research Institute in the Philippines has reported that at present "there is almost no gap between the experiment station and the farmer yields and the long term prospects are for a stagnation and/or decline in average farm yields." While some countries are reporting significant gains in per capita food production, quite a number of countries are experiencing per capita declines. Africa is most notable in this regard; the overall index of agricultural production per person has declined by eight percent between 1976-78 and 1986-88. Asian and Latin American countries have also experienced a similar trend.

Many people seem to hold the mistaken notion that agricultural production technologies can directly substitute for degraded resources. For unirrigated agriculture, which comprises 85 percent of the world's cropland, this is a particularly dangerous assumption. While modern technologies, such as high-yielding crop varieties and agrichemicals, can improve potential production, it is invariably true that more of this potential can be achieved if soils are not degraded. In this sense, healthy soils and advanced technologies are complementary, and not substitutes for one

another. Improved seed varieties that are better able to handle stress, for example, may only serve to maintain, and not improve yields, if erosion is simultaneously damaging the soil's ability to absorb and hold water. It is crucially important to maintain the productivity of natural resources in order to realize the potential of future technological advances in agriculture. This may be particularly true for biological diversity, an asset of enormous potential value as researchers expand our capabilities in the area of genetic engineering.

As if the difficulty of meeting future food demand with a declining resource base were not challenging enough, we may also be facing climate changes which could make the task significantly more difficult. The consensus among climatological forecasters is that we have locked ourselves into at least a few degrees of global warming. If these predictions come true, the disruptions caused by changing weather patterns could be serious for agriculture. For example, drier weather has been predicted for major production areas such as the Midwestern US and the Indian sub-continent. Aside from the implications of drought, higher temperatures would make some crop varieties unproductive. It has been estimated that an increase of 1 to 2 degrees Celsius in India's Northwest would make current varieties of wheat nearly infertile.

Agriculture can probably adapt to many of these changes, given sufficient time and a robust natural resource base. But, just as

unhealthy plants are much more susceptible to disease and insects, depleted natural resources will make agriculture more susceptible to global climate change. In order to adapt to global warming, agriculture must be on a sustainable footing **before** major changes take place.

III. How to Achieve Sustainability in Agriculture

The practices that we call "conventional" today, have become so because the economic incentives have induced farmers to adopt these practices on a wide scale. In turn, agricultural policies have played a major role in shaping the economic incentives that farmers see. Today if we find agricultural production systems that degrade and deplete natural resources, much of the blame must be placed at the foot of the agricultural policies that nations have adopted.

If the costs of using energy, water, fertilizers and pesticides are heavily subsidized, as they are in many countries including the United States, it should come as no surprise that these inputs are used inefficiently. And, if inputs are used inefficiently, we should expect resource degradation to be the result. If pesticides are subsidized, we should not expect Integrated Pest Management practices to be adopted or crop rotation to be a common practice. If energy or irrigation charges are subsidized, we should not expect farmers to use water efficiently

or to adopt water-conserving technologies. If fertilizer is subsidized, we should not expect farmers to use green or brown manures.

Agricultural policies can also inhibit research in resource-conserving agricultural practices. Agricultural research is driven by the perceived scarcity of factors of production. In the post-World War II era, the focus has been on technologies to balance rising land or labor costs. Land- and labor-saving technologies, particularly those dependent upon relatively low energy prices and on chemical fertilizers and pesticides, have received the bulk of research efforts and pesticide and inorganic fertilizer use has become the norm in many areas. Agrichemical use has been positive in many ways, allowing tremendous increases in food production.

Methods of soil management, nutrient supply and weed and insect control requiring more land, labor, or management, as is often the case with resource-conserving farming systems, have not been favored by research establishments. Farming systems that minimize natural resource costs have been almost entirely ignored.

Today's situation is something of a Catch-22. Many farmers use chemical- and energy-intensive production technologies because they are available and profitable. These technologies have been made available, in part, because research establishments respond to economic incentives and to what farmers want. If farmers do not

"demand" production technologies that conserve and regenerate the natural resource base including soils and water, they will not get them, and most farmers will not demand them if agricultural policies make their use less profitable.

The first, and perhaps the most essential, step that we should take to ensure agricultural sustainability is to ensure that agricultural policies encourage the adoption and generation of resource-conserving technologies. It is absolutely necessary that agricultural policies provide farmers with financial incentives in line with the underlying resource economics. In both developed and developing countries, the distortions that mask the costs of natural resource degradation must be removed. In the United States this means providing farmers income support in ways not connected to commodity production. In developing countries this means the elimination of input subsidies and the provision of fair crop prices. Unless farmers face the environmental costs associated with agricultural production, agricultural sustainability will not become a widespread reality.

MATERIAL SUBMITTED BY PETER S. CARLSON, CROP GENETICS INTERNATIONAL

Chapter 30

Creating Value with Agricultural Biotechnology

Developing World Applications

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Agricultural Biotechnology in the Developing World

In the absence of real world examples or concrete results, the potential utilization of plant biotechnology in agriculture, particularly in the developing world, is like a Rorschach ink blot test; the viewer experiences subjective rather than objective reality. The problem is particularly acute in attempts to divine the utility of new technologies in altering the productivity of small holding, primarily marginal farmers in the developing world. Plant genetics in actual fact, will probably not play a major role in changing the condition of such indivviduals when compared to political and economic forces. However, the role of plant genetics appears real and not inconsequential: improve seeds of planting materials are an often cited need for these farmers. Improved seed probably holds as much potential for helping small farmers as any other single agronomic input. What types of genetic alterations are appropriate for the needs of developing world agriculture? Certainly, the agronomic situation of the small, marginal farmer is different from that of the large commercial farmer common in the developed world. It is impossible to transfer standard developed world farming technologies if there is not the ready availability of chemical and physical means to manipulate the environment. Additionally, the economic (e.g., market price, access to credit) and politiccal (e.g.,, land tenure arrangements) constraints are beyond immediate control.

Small farmers have responded with a diversity of solutions to their individual situations. It appears as if there is one central theme in all of the various viable solutions: to develop a defensive stance. In agronomic terms this may mean a diversity of crops for home consumption and for the market. In biological terms this implies genetic variability. Some risk is

0097-6156/88/0362-0361$06.00/0
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acceptable, but not too much. Some harvest is preferable to no harvest, and when there is little control over the environment, or limited agronomic inputs, the genetic composition of the crop becomes an important consideration. This defensive stance may alter the plant breeder's strategy: increasing yield, while continuing to be an essential breeding objective, becomes of secondary importance when compared with survival and adequate levels of production under the entire range of possible environmental (physical, chemical, and biological) conditions. Hence, a major concern for crop improvement must be to maintain and increase the range of genetic variability which permits a crop species to survive and be productive under widely different conditons. The production and analysis of genetic variability and its incorporation into adapted varieties is an appropriate goal to aid these farmers. The ingerent strength of conventional plant breeding techniques and new biotechnical manipulations for the small farmer is that they are potentially scale neutral, politically neutral, relatively inexpensive for the farmer, andd can involve few ties with commerical networks. These qualities make plant improvement programs and their results accessible to small farmers and acceptable to governmental agencies and international developmental efforts. While the crop improvements provided by the "green revolution" have not always been of this nature, there is no reason why the technologies of breeding and genetics cannot accomplish these goals.

Commerical incentive is the driving force behind the development and application of biotechnology in the developed world. I doubt this engine will work in less-developed countries primarily because the financial opportunities do not balance the science and market risks. The burden of application must be shouldered by the public sector. This task demands uncommon wisdom and forethought in formulating policy. I base my conclusion on the following considerations:

1. Science does not exist in a vacuum; economic, social and political forces determine which technologies are utilized. Inexpensive, proven technologies are, under ordinary conditions, preferred by the market. Biotechnology is in many instances neither an inexpensive nor proven methodology for crop improvement.

2. Currently utilized agricultural technologies work. In the developed world, the food machine isn't broken! In fact, the machine is running too fast already. The world suffers from massive overproduction of foodstuffs and declining prices for such products. What needs fixing is the production/delivery/market infrastructure in nations experiencing famine, and

more rational ecological policies to reverse the expanding desert and shrinking tropical jungles. Indeed, a policy using biotechnology to increase developed country food output might make a bad situation worse.

3. The use of biotechnology to create novel crop varieties is generally not a business with attractive return on investment. No matter how carefully crafted the patent protection may be, as a practical matter for many crops the farmer's field is a genetic Xerox machine.. The onetime sale by the biotechnology breeder of a new variety can not support a price structure adequate to cover research costs. The extra effort to hybridize a new variety to create a "repeat sales" opportunity is substantial. Seen in this context, agricultural biotechnology may be an "orphan technology."

4. The farmer is a price and risk sensitive consumer, and is extremely reluctant to increase the portion of his costs devoted to planting materials at the beginning of the growing season. Biotechnology is an expensive undertaking and an additional cost in varietal production. The added value created by biotechnology manipulations will not be reimbursed by the market.

5. Technology transfer is not a generic exercise. Manipulations which ahve been defined for use with tomatoes will not be directly applicable to bananas. Goals for the improvement of corn are inappropriate for cassava. Agronomic goals for rice production in Japan are wholly different from those in India. In this light, the question of who "owns" or "controls" new technology is absurd. The underlying science of biotechnology can not and will not be effectively protected. Additionally, the developing world has access to the world patent literature and is under little or no constraint to abide by intellectual property laws in force in the developed nations. Private industry in the developed nations will not undertake work aimed at modifying tropical crop species in the absence of protection and a clear return on investment.

6. The information base for tropical crops is much smaller than that for the annual temperate species making technical applications more diffficult. Crop productivity or crop yield is a quantity often expressed in bushels per acre, tons per acre, kilograms per hectare, or jin per mu. This notation is a physical description of a biological endpoint, for productivity is the sum of the biological

components which result in a population of mature plants. Although this expression is often a satisfactory one for farmers, ecconomists, or statisticians it hides the extent of our biological ignorance. Not enough is known about the underlying biology which directly or indirectly determines crop yield. Furthermore, what is known is inadequate for our needs. Contemporary research efforts have revealed and will continue to reveal new methods for genetic manipulation with higher plants. These new methods, should be of direct utility to plant breeders and agonomists in the developing world. To adequately utilize the techniques, it is important to have a clear biochemical description of what needs to be altered. What are the biological limitations of plant growth and productivity, and how does this biology interact with the environment? Defined genetically, encoded processes can be genetically manipulated while kilograms per hectar cannot.

International agricultural biotechnology laboratories located in the developing world should focus their effort on the extension and application of existing technologies to tropical crop species and the particular needs of tropical agriculture. The extension andd application of existing technologies is, at the current time, a more important and clearer goal than the invention of new science. It is the strategy that the CGIAR Institute have successfully utilized.

An Example of Biotechnology Extension and Application

The utilization of plant tissue and cell culture techniques in plant improvement may well have its greatest impact in those crop species whicch are clonally propagated, e.g., bananas, sugar cane, yams, cassava, potatoes, tree species, etc.[1] Prolific plantlet production from meristems and other tissue sources facilitates rapid propagation of plants with elite genotypes in crop species not easily propagated via seeds. Meristem culture techniques also provide the basis for elimination of systemic diseases from planting materials.

Plants regenerated from longer term callus or suspension cultures often show an increased genetic variation which has been reported to be of value to breeding programs in perennial crop species. Genetic variation produced during tissue culture of sugar cane has resulted of several new disease resistant clones[2,3,4]. Similar variation resulting from the culture of potato protoplasts is now being utilized by breeders as a source of disease resistance and greater adaptability to environmental extremes[5]. The increase in genetic variability due to passage of cells through

tissue culture has also been described in other crops such as rice, oats, wheat, lettuce and tomatoes[6].

The primary application of increased genetic variability resulting from tissue culture has been the recovery of new genotypes with increased tolerance to plant diseases[6]. Tissue culture variation is superimposed directly upon existing qualities of a cultivar. This theoretically allows the introduction of alterations in single traits without the segregation of a vast array of alleles as in a sexual cross[2,6]. Passage of plant tissues throgu in vitro culture combined with selections of the resulting genotypes for their response to plant pathogens constitutes a method for improving a well adapted or successful variety by the addition of single disease response characteristics.

Bananas and Black Sigatoka

Bananas are an unusual agronomic crop since only clones selected from nature are currently cultivated. Commercial banana clones are vegetatively propagated, parthenocarpic triploids and are sexually sterile. Consequently, the standard techniques of plant breeding based upon sexual crosses can not be utilized for banana improvement[7]. Only two major clones (Gros Michel and Cavendish) have been acceptable for the export trade[7], and are important sources of export income for a number of developing nations. Diploid bananas, which are sexually fertile,, are not grown for export since their fruit size and plant vigor are unsuitable.

No crop species better illustrates the biological dangers of a genetic monoculture than bananas. Panama disease, or fusarial wilt (caused by Fusarium oxysporum Cubense), became a serious problem in Gros Michel in the 1940's and by 1955 had made cultivation of this cultivar unprofitable. Approximately 100,000 acres of bananas were destroyed or abandoned in central America because of this disease[8].

Cavendish clones resistant to Panama disease were substituted for Gros Micchel during the 1950's and 1960's creating a new monoculture of the variety. There are several different Cavendish subclones which vary in height but are all essentially genetically identical[9]. No known natural or selected clones exist as possible commercial alternatives to the cavendish cultivars[10].

The Cavendish cultivars are susceptible to a destructive and costly disease. Since 1933, Sigatoka leaf spot or Yellow Sigatoka (cause by Mycosphaerella musicola), has been a potentially serious disease in the Central and South American regions. However, routine

and inexpensive control measures were able to contain the spread and moderate the destructiveness of this pathogen[11]. Black leaf streak, a more severe strain of M. musicola, was present in the Pacific region for many years, but was not found in Western Hemisphere[12]. In 1972, a more virulent Sigatoka leaf spot pathogen, apparently caused by a mutation or sexual recombination of M. musicola, was identified in Honduras[13]. This new fungal leaf spot pathogen, termed Black Sigatoka (Mycosphaerella fijiensis var. difformis) has greatly increased disease control costs andd currently threatens the export banana industry in the Americas. Since the original epidemic in Honduras in 1973-74, this disease has spread throughout central and South America and the Caribbean Basin region.

New genetic variation is needed in Cavendish cultivars to protect this industry against another devastating epidemic. Genetic resistance to Black Sigatoka in Cavendish cultivars would also reduce production costs. Sources of genetic resistance to Black Sigatoka have been identified in several selected clones of the diploid banana species Musa acuminata[14]. However, this genetic resistance cannct be incorporated into Cavendish varieties because of sexual sterility[15]. An alternative method for genetic manipulation of Cavendish clones wouuld be to induce somatic mutations for Black Sigatoka resistance by using ionizing radiation and other mutagens on plantlets, followed by selection of increased disease tolerance. However, several attempts at using mutation breeding methods to recover Black Sigatcka tolerant subclones of Cavendish bananas have not been successful[15].

Genetic variation occuring in tissue culture holds promise as a useful technique for recovering Black Sigatoka resistant Cavendish clones. The use of tissue culture is a realistic alternative because:

1. Genetic variation cccuring in cell and tissue culture is a proven technique for the production of disease resistant or tolerant genotypes in a range of crop species[2,3,4,5,6].

2. Even though our knowledge of banana tissue culture is not complete, there has been some progress over the last several years[18]. It is now possible to regenerate large numbers of plants from callus cultures of Cavendish bananas and to identiffy somaclonal variants within this population of regenerated plants[20]. We can expect the remaining major problem, that of plantlet regeneration, from suspension and protoplast cultures, to be defined within several years if an intensive effort is initiated[19].

3. The Black Sigatoka fungus appears to produce a toxin. Related fungi in the genus Cercospora produce a phytotoxin, Cercosporin, which can readily be isolated and potentially used as a direct selective agent for increased disease resistance or tolerance[20,21,22,23].

4. Resistance to Black Sigatoka in wild diploid banana species is controlled by one or only several genes. This relatively simple genetic system is well suited for manipulation by tissue culture techniques[10].

Several different selection systems could be employed to produce Black Sigatoka resistant banana clones:

1. A large number of plants could be regenerated from callus cultures and examined for their reaction to Mycosphaerella fijiensis var difformis by direct inoculations. Techniques for greenhouse inoculations have been established[25]. If insufficient variability is produced by passage through culture, chemical and physical mutagens could be employed. This approach is currently available[19].

2. The phytotoxic chemical or chemicals produced by M. fijiensis var difformis could be used as a selective agent in tissue culture to recover resistant cells and calli. These resistant calli could be regenerated into plants and examined for tolerance by direct inoculation with the disease fungus.

3. Cercosporin, a phytotoxin produced by a related fungus, is known to act by producing singlet oxygen and superoxide radicals when exposed to light[25,26]. The Black Sigatoka toxin appears to act in a similar fashion[21]. Tobacco cells resistant to a superoxide radical producer, the herbicide paraquat, show a slight increase in tolerance to Cercosporin. Selection of banana cells which are resistant to paraquat followed by regeneration of entire plants and examination of the reaction of these selections to Cercosporin and to M. fijiensis var difformis by direct inoculation could be accomplished. A similar protocol ccould be established with agents that produce singlet oxygen radicals.

4. Conditional lethal mutants (temperature sensitive) of M. fijiensis var difformis could be produced for use in co-culture selection systems. Banana suspension and callus cultures could be co-cultured with conditional lethal mutants of the pathogen can attack the plant cells. Growth of the pathogen

could then be halted by shifting the co-cultures to non-permissive conditions. Banana cells and calli able to resist infection by the pathogen and survive in tissue culture could be regenerated into plants and examined for plantlet resistance by direct inoculation.

5. Black Sigatoka resistant diploid banana species could be established in callus and suspension culture and the response of these tissue cultures to M. fijiensis var difformis and its toxin could be analyzed. The characterization will be utilized to develop selective systems not obvious from our current knowledge of the host-pathogen interactions.

6. Protoplast fusion could be attempted between the Cavendish variety and resistant diploid banana species. This approach would constitute a last resort since protoplast technologies appear more remote with this genus than do suspension culture methodologies.

Once Black Sigatoka tolerant plantlets have been recovered, evaluation of yield and other agronomic characteristics of the selected subclones would be undertaken. Subclones which maintain the characteristics of the parental Cavendish cultivar and demonstrate resistance or tolerance to Black Sigotoka would then be chosen for mass production via rapid shoot tip propagation.

This type of technology extension is unlikely to be undertaken by a private company for the following reasons:

1. The project requires tremendous up front research costs with no guaranteed success.
2. There are no ready customers willing to pay the price for an improved CCavendish clone, or for the research costs.
3. An improved Cavendish clone represents a one-time sale since it is not legally protectable.

Consequently, this project appears ideal for execution in a publicc sector laboratory in the developing world.

It is important to realize that bananas have enormous importance in the developing world beyond the export value of the crop. Of the approximately 12 billion bananas produced annually, 80% are consumed locally in the dcmestic market of the producing country. Domestic consumption is primarily of a large number of varieties different from the Cavendish produced for

export. The majority of these local cooking banana and plantain varieties are also susceptible to Black Sigatoka, threatening an important developing world food source. Once proven methodologies and manipulations have been defined for recovery of Musa sp tolerant to Black Sigatoka, they could be rapidly transfered to regional or national laboratories for use with locally adapted and accepted cultivars.

Although this banana project is presented only as an example, it embodies criteria appropriate for emphasis in developing world institution. These criteria include:

1. A clear developing world need that cannot, or will not, be filled by existing institutions.
2. Minimal resulting social disruption or impact.
3. Technical feasibility by extension of existing technologies.
4. A relatively short horizon time.
5. Definition of routine manipulations transferable to regional or national efforts throughout the developing world.

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RECEIVED September 3, 1987

Reprinted from ACS SYMPOSIUM SERIES No. 362
The Impact of Chemistry on Biotechnology: Multidisciplinary Discussions
Marshall P. Phillips, Sharon P. Shoemaker, Roger D. Middlekauff, and Raphael M. Ottenbrite, Editors
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Committee on Agricultural Sustainability

for Developing Countries

June 5, 1990

To Feed a Hungry World: The Urgent Role of the Development Agencies

Executive Summary

The Committee on Agricultural Sustainability for Developing Countries is often asked what kind of agricultural policies and programs it would like to see the development agencies carry out -- and how the principles of agricultural sustainability should be applied to these programs. This policy study is an attempt to answer those questions, to outline the present urgent context of agricultural development, and to set forth priorities which we believe should guide the attentions of the development agencies.[1]

The Urgent Context of Agricultural Development

Never before have the prospects for feeding the world been so problematic. With millions in the developing countries already hungry, the world faces the prospect of a 40 percent population increase within two decades. Most will live in the developing countries of the tropics and China. Producing food for all these people in a sustainable way plus producing more and better food as demanded by newly affluent groups is already putting an unprecedented strain on the world's agricultural systems.

Easy or widely applicable solutions to this problem are likely to prove elusive. Relatively little new arable land is left to be brought into production, while the present area of productive farmland is likely to be sharply reduced as farms go out of production from erosion, salinization, waterlogging, and decreased fertility. About 7 million hectares of agricultural land is abandoned each year because it is so badly degraded that it is no longer productive.

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[1]Putting together a set of recommendations which can apply to all the development agencies is a task fraught with chances for overstatements and overgeneralization. Generalizations about program and past performance that we've had to made cannot fairly apply to all development agencies, and we ask our friends in those agencies not to be hurt if the shoe does not fit them. We also recognize that abbreviated discussion of complicated developmental questions -- made for the sake of brevity -- can often do little more than suggest a topic for broader examination. For all this we ask our colleagues' tolerance.

Nor is any major scientific breakthrough in sight which could result in rapid productivity increases such as happened as a result of one "green revolution" of the 1960s. The principal way that most farmers will have for increasing productivity will be to change the way they manage their lands.

Sustaining productivity on the most productive lands is extremely important and will not be easy. But wringing more productivity from better management will be particularly tough for farmers working the less well-endowed lands -- lands that are too cold, too steep, or too dry, and lands with problem soils. Yet, it is imperative that this be accomplished. Better land management is especially urgent in the many countries where a significant percentage of agricultural production comes from the less well-endowed lands, and which provide livelihoods for a large proportion of farm families.

Despite all these difficulties and despite the obvious need to generate new technology to help farmers achieve sustainability in production, enough improved plants and farming methods are already available to allow farmers to make some real gains. And making small but steady gains that will at least exceed the rate of population growth, as difficult as this may prove to be, are urgently needed.

The big problem is and will remain getting the new techniques that will make this possible out to the farmers, and convincing them that their interests will be served by adopting them. In too many countries, official extension services won't be of much help in this process. Too many are so institutionally and politically weak and so isolated from the small farmer that they cannot be strengthened quickly enough to become major players in this urgent game. Under the circumstances, in many countries the best of a bad situation can be made by working with and through non-governmental organizations, particularly strong community-based organizations.

A New Role for the Development Agencies

If development agencies can make the institutional changes required by the times and develop the necessary sense of urgency, they will continue to provide the best framework available for organizing, financing, and carrying out the increasingly collaborative efforts required to stave off a major crisis in food security.

But to be successful, development agencies' policies and programs must reflect fundamental changes that are taking place. Instead of yesterday's role of being the purveyors of the developmental "wisdom," today's development agencies must strive more and more to provide a broad framework for enlightened collaborative efforts between the developing countries and their

industrial country partners. Instead of, as now, just concentrating largely on working with governments, development agencies must also adapt to and indeed encourage worldwide trends toward devolution of power and function to regional and local authorities and organizations, private as well as public.

We suggest that development agencies should, for the next decade at least, focus their agricultural development policies and programs on four overriding objectives:

1). Helping developing countries and their farmers protect and conserve soil, water, energy, and the biological resources necessary for sustainability.

2). Helping developing country governments and their farmers to adapt agricultural policies and practices to the principles of sustainability.

3). Helping developing countries to achieve a sustainable increase in their agricultural productivity to the point where countries realize a high degree of food self-reliance.

4). Helping developing countries rationalize every aspect of their agricultural economies in order to grow in ways that will raise the living standards not only of farmers -- including especially poor farmers -- but also consumers. Agricultural economies must once again be made the engine for more dynamic overall economic growth.

Moreover, the development agencies must make their contribution to collaborative agricultural efforts in a way that helps farmers and governments understand environmental values and in ways that do not cause environmental damage.

In this process, each development agency will have special interests to serve and special strengths to call on. They also have other programs -- population programs, health and education programs, programs for women -- that will contribute to the achievement of these objectives. But it is precisely the achievement of these primary objectives that must remain central to the work of every agency -- without distraction and with the reliability and continuity required of such a difficult and urgent effort.

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A Basic Agricultural Agenda for Development Agencies

To achieve these objectives soon enough and on a large enough scale to meet the problems of sustainability and food security, development agencies must find ways to give -- or continue to give -- certain programs a high priority:

1). Programs for Helping Farmers Gain Access to Improved Plants and Farming Practices

Working closely with the international agricultural research centers, with the better national agricultural research centers, and increasingly with non-governmental organizations and universities, the development agencies must do their best to generate better farmer-tested plants and farming practices -- for pest management, soil improvement and conservation, cultivation techniques, and water use and conservation techniques, to mention a few. To be useful to farmers, these practices must also be adapted for local conditions. Better means must also be found to advertise the existence, the source, and the potential of new field-tested cultivars and farming practices to a much broader network of agriculturalists.

2). Programs for Direct Help to the Farmer

Once better plants and farming practices are field-tested, the problem is getting the most useful ones into the hands of the farmers who can benefit from them, something that is too seldom happening now. The classic way for development agencies to try to help has been by building up the capacity of national extension agencies to reach the farmers. In the longer-run, and now in some countries with strong extension institutions, this may still be the best way to go. But where national extension agencies are not yet strong enough or respected by farmers, development agencies should do more to seek out, strengthen, and develop ad-hoc ways of cooperating with community-based organizations that already have a good track record for working with farmers. These organizations can then recruit larger groups in spreading successful efforts over much wider areas.

3). Programs for Helping Governments Rationalize Their Agricultural Economies

If we have chosen to give priority to the need to give more direct help to farmers, we also support other development agency programs that enhance the prospects for sustainability -- for the farmer as well as for the nation. Development agency help in building, rebuilding, and maintaining rural infrastructure continues to be very important, but only if such infrastructure cannot be financed through the growing

global capital markets. But infrastructure financing must not be allowed to diminish production assistance to farmers. The same must be said for structural adjustment programs, which, while useful, cannot by themselves solve the urgent problems of increasing farm productivity.

4). Programs for Agricultural, Natural Resource, and Environmental Planning and Training

Helping people in developing countries -- in government and in the private sector -- to recognize, analyze, and then tackle agricultural problems, particularly in the context of new insights about natural resources, must continue to be a very basic part of development agency programs.

5). Support for Especially Important Agricultural Programs

(a) Programs for Rationalizing Chemical Fertilizer and Pesticide Use, and Support for Integrated Pest Management Research and Use

Chemical fertilizers, though liable to be increasingly expensive and even unavailable to poor and remote farms, continue to be essential tools for nutrient supply -- when not overused or used incorrectly. Development agencies should seek to play a more aggressive role in rationalizing their use. Agencies must also pay special attention to how they advise and subsidize chemical pesticide use because of dangerous health and insect resistance-building side effects. With insect resistance growing rapidly for an increasing number of crops, the development and spread to farmers of farmer-friendly integrated pest management methods must have a high priority.

(b) Programs for Secure Land Tenure

As difficult as land tenure programs have proven to be, security in tenure is essential if farmers are to have the motivation to work harder for the preservation of the soil, trees, and water on which greater productivity depends. Stronger support by development agencies for such programs will be needed.

(c) Watershed Protection Programs

Successful watershed protection programs are urgently needed to help preserve productivity on well-endowed downstream lands. Success is not easy because it depends on actions of millions of upstream farmers who seldom receive rewards commensurate with their labor. If successful, however, they have the advantage of assuring the continuity of other essential environmental services.

(d) Land Use and Agro-Forestry Programs for Development in or Near Forested Areas

Given the urgency of protecting the biomass and biodiversity represented by tropical forests, development agencies must continue to recognize the extreme caution with which agricultural development in or near forests, let alone resettlement projects, must be approached.

The Central Importance of Population Programs

Even in the mid-term, nothing that development agencies do to help developing countries achieve sustainability and food security has a long range chance of success unless explosive population increases are stopped. For this reason, we urge development agencies to give the highest priority to aggressive support for family planning programs.

Conclusion

The recommendations put forth here are admittedly ambitious, difficult, and in some respects novel. However, much larger and better coordinated efforts must be launched -- and very soon. The penalty for inaction or for inadequate action will not only be the degradation of resources vital to productive agriculture -- soil, water, energy, and a whole range of biological resources, but -- very much to the point -- an enormous additional amount of human suffering. Success will require early action by development agencies to recruit more well-trained people and, in some cases, to make major institutional changes. Most will also have to commit a higher percentage of their budgets to agriculture -- and for a longer period. But the need for a radical transformation in the agriculture of developing countries is so grave that these shifts in emphasis and increases in resources must be made without delay.

TO FEED A HUNGRY WORLD: THE URGENT ROLE OF THE DEVELOPMENT AGENCIES

Enthralled by recent worldwide strides toward greater personal and economic freedom, is the world now in danger of failing to take the most basic actions needed to preserve this freedom? Indeed, what is more basic than the need to eat?

Meeting this challenge will mean finding food for a global population that will grow by 40 percent in two decades, and growing that food on much less land than is in cultivation today. The amount of farmland is likely to be sharply reduced as farms go out of production from erosion, salinization, waterlogging, and decreased fertility, and little new land can be brought into production. Already, per capita food output -- perhaps the best measure of agricultural adequacy -- is decreasing over much of Africa and parts of Latin America. Millions of people -- and not just in Africa -- are on the brink of starvation. Population growth will eventually stop, but probably not before early in the next century, when it reaches somewhere over 8 billion people -- a huge number of people to feed. Most will live in he crowded countries of the tropics and in China. The world has heard predictions of food crises before. But never has there been evidence so difficult to refute that a crisis could lie only a few years ahead.

Can the world feed all these people? It's not clear. Finding any overall solution is likely to prove elusive. But what is clear is that the human and the political costs of not trying are unacceptably high. It is also clear that unless there is some real success in fundamentally changing the way that agriculture is carried out, particularly in developing countries, and unless resources large enough to do this job are mobilized very soon, developing countries have little hope of producing the food they will need to avoid much greater suffering even a decade from now. The longer that we postpone effective and broad-scale efforts to make agriculture sustainable,[1] the more costly and more

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[1]Our Committee defines agricultural sustainability as the ability of an agricultural system to meet evolving human needs without destroying and where possible improving the natural resource base on which meeting these needs depends.

While this broad definition has some conceptual and symbolic values, the Committee attaches greater practical importance (a) to defining and determining what is sustainable at a given place and at a given time; and (b) to examining thoroughly not only the ecological and economic sustainability of a farm and its practices but also the cultural acceptability of proposed changes, the institutional and political sustainability of those changes, and the supporting local and national institutions and infrastructures.

questionable the results will be and the more serious the political and economic consequences of failure -- for this country and for the whole world.

Yet, paradoxically, evidence suggests that real progress can be achieved toward making agriculture sustainable if early action is taken by national governments, by the world's development agencies, by scientific and research institutions, by community-based organizations, and, ultimately and most importantly, by the world's farmers themselves. What are the basic building blocks for such progress? It cannot come from any appreciable expansion onto new lands, for very little good land remains unexploited. Nor does anything on the horizon indicate the possibility of another major scientific breakthrough that could rapidly boost food-crop productivity like the "Green Revolution" of the 1960s. Classic plant breeding will continue to produce small -- and important -- gains. But for the next decade at least biotechnology is not likely to lead to big advances in productivity. However, recent studies suggest that there is already enough farm-tested technology to allow small gains in agricultural productivity and natural resource protection from better management. Some important gains will come from irrigation and from externally-supplied nutrients. But it is from improved ways of growing food and better protection of natural resources that most of the gains must come.

There is no time to lose, however. The physical environment of soil, water, energy, and biological resources, already badly degraded, is in many of the developing countries deteriorating to the point that it can no longer provide a living for hundreds of millions of farm families, let alone provide more and more nutritious food to meet the demands of rapid urban growth and greater affluence among the expanding middle classes. About 7 million hectares of land is abandoned each year because it is so badly degraded that it is no longer productive. Early political action is needed to make available a critical level of resources -- more well-trained people, more money -- and to assure the high priority necessary for success.[2]

Who can play central roles in such a huge endeavor? Many institutions and individuals. The developing countries themselves -- and particularly their farmers -- will have the greatest responsibility. But among outside forces, the development agencies -- the World Bank, the regional banks, and the national aid-giving institutions -- plus the great international agricultural research institutions must obviously take the lead. These strong and experienced organizations are the most hopeful focus around which

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[2]While this paper emphasizes the dangerous loss of physical resources in the developing countries because this is where development agencies principally work, the same problems also exist to a dangerous extent in many of the industrial countries.

to rally the money, the technical capacity, the framework for action, the leverage with the governments of developing countries, and the positive motivation needed to move farmers and governments fast enough to avoid disaster. If research and experience show anything, it's that these institutions can, if they individually and collectively develop the necessary sense of urgency, if they gather the will, the organizations, the resources, and the political support, and if they make the institutional changes required by the changing times, they can successfully take on the tasks of promoting agricultural sustainability and food security. These institutions must also work out, constantly refine, and put into practice a common strategy and division of labor among themselves, developing country governments, and other partners.

But assistance to developing countries predicated on economic and political conditions that existed in the 1960s and 1970s or even the 1980s will not be effective or saleable today. A new development paradigm and new ways of working together are emerging and should be refined and supported by the development agencies. What are these new elements? An increasing emphasis on the environment and on natural resource management is the most obvious additional dimension, and much of this study will involve exploring its ramifications. A second is the need to concentrate more effort on helping the farmer conserve his resources and raise his productivity. Closely associated is the need for governments and development agencies to find better ways to work with community-based farm organizations and other non-governmental organizations. Working efficiently and effectively on the small-scale required at this stage of agricultural development is a capability that must be developed by all organizations committed to change in the 1990s. And basic to every aspect of the new development paradigm is a new spirit of collaboration, of greater equality among partners, of genuine participation by people at every level from the woman farmer helping with the design of research projects to the regional agricultural planner working with a development agency in making mid-term corrections to projects.

On the political side, problems for the availability of resources for assistance to developing countries will flow from increased attention to Eastern Europe and the consequent tendency in a world of finite budgetary resources to downgrade assistance to the developing countries. This means that a stronger political and economic case for assistance -- and as a priority agricultural assistance -- must be made, one that is based on a realistic assessment of the importance of the developing countries to the rest of the world and of their growing importance in trade, in security, and in the solution of urgent common problems.

There is another factor that must merit continuing close attention: the trend toward downgrading dependence on governments and governmental economic intervention for the sustainable growth which developing countries with rapidly growing populations must

have if they are to avoid a disastrous reduction in their standards of living. Certainly the weakness, inefficiency, and unresponsiveness of government agricultural institutions in many developing countries bears out the validity of this trend. Some suggest that "the market" can replace government investment and control as the engine of growth. While sometimes valid for more dynamic sections of developing countries' economies, market conditions alone cannot be counted upon to produce a better living, let alone increases in agricultural productivity, for poorer farmers living largely outside the market. A better combination of national, regional, and local governmental and private efforts must be found to achieve this purpose.

There is an associated trend in developing countries that deserves sympathetic stimulation: the decentralization of authority and responsibility to regions and to localities -- not only to local and regional governments, but also to locally based "popular organizations." To some extent this is an encouraging return to successful models employed in the past in many cultures to organize effective rural action.

A final change that must be reflected in assistance to developing countries is the need to recognize that the day of the expatriate advisor "handing down wisdom from on high" is over in the developing countries. Now and henceforth, for sound psychological, practical and political reasons, the framework must be one of collaboration between equals -- and for mutual advantage. And there is no doubt that the industrial countries have much to learn and to gain from this kind of collaborative effort.

The Four Goals of Agricultural Assistance

No more basic task faces the developing countries and the world than the protection and where possible the restoration of the natural resources (soil, water, energy, and biological resources) on which production of the food needed to feed the world depends. Much of this depends on the actions of millions of farmers. But helping farmers acquire the knowledge, the confidence, and the incentives to conserve is a task to be approached at many levels -- the community-based organization, the extension systems where farmers have confidence in them, the regional and national governments. Stopping the degradation of soil and conserving and protecting water supplies under the conditions of growing population pressure is about as difficult a job as any faced by developing countries. Development agencies have an essential role to play not only in helping finance protection efforts -- from farm-level initiatives to watershed protection projects on communal or national land. Development agencies must not be scared of this task because of its complexity and cost -- or because of the reticence of some governments to give high enough priority to these tasks, tasks which have little short-term political payoff.

We must not underestimate the difficulties of achieving agricultural sustainability and at a level high enough to provide food security. Even today, much of the world's agriculture is clearly unsustainable. Sustainable agricultural systems are obviously needed for all countries including the industrial countries. But the establishment of sustainable systems for the developing countries is given special emphasis because high rates of population growth, rapid resource degradation, and the prospects of food shortages make it so very urgent. As a matter of high priority, ways must be found to keep in production until recently sustainable systems of slash-and-burn agriculture found on every continent -- the lower end of the productivity scale. But even for the world's most productive systems such as the ancient rice-paddy cultures of South and Southeast Asia new ways must be found to keep them sustainable. Without continuing research, viable systems can all too easily become insupportable. The truth is that the agriculture of every country in the world faces serious new and continuing problems, environmental and otherwise. Nonetheless, the problems faced by the tropical developing countries and China are of a very much higher order of magnitude because of the conjunction of rapid population growth with widespread deterioration or fragile natural resources. All of this indicates that helping developing countries to achieve agricultural sustainability must be an urgent priority for the world's development agencies and a focus for their agricultural programs and policies.

Yet, as we have already indicated, agricultural systems must not only be sustainable. They must also be productive enough -- over the longer run -- to provide countries with reasonable food security. Certainly, not all countries have the need or the potential to achieve food self-sufficiency. Many -- the desert countries of the Middle East, for example -- must already depend on food imports. Others will maximize their overall advantage by importing a portion of their food, as long as they can generate the necessary foreign exchange to pay for it and as long as the poor who may depend on imported food can afford to buy it.

But recent history has shown that over-reliance on food imports can quickly cause problems. Dependence on food imports -- through trade or relief -- has too often destroyed developing countries' capacities to feed their people when circumstances change. As global food supplies tighten, the search for greater self-reliance in food production is the most rational course for a good number of countries. Thus, the agricultural programs and policies of development agencies must have a third focus in addition to sustainability: to help developing countries achieve longer-term food self-reliance.

A fourth (and more traditional) focus for development agencies must be to help developing countries strengthen and rationalize every aspect of their agricultural economies. Agriculture cannot

become sustainable just by helping farmers. Governments have a responsibility to their people to develop some level of national agricultural research capacity to allow them to profit from and adapt to local conditions internationally-generated technology. Government policies must be supportive of farmers and the rural sector -- and must be seen as such. And the right kind of rural physical infrastructure, marketing, and credit institutions must be in place. Governments must also understand the importance of moving rapidly toward agricultural sustainability and food security, and must understand how they can do this. The development agencies can use more of their combined intellectual and political leverage with governments to achieve these objectives.

The end result of all these efforts should be stronger and more equitable agricultural economies which can meet national and global needs for food and fiber and for a clean environment, can provide higher living standards for farmers and consumers, and can be the engine for growth in the whole economies of developing countries. For experience throughout the developing world has shown that growth in the agricultural sector has been the essential engine for overall economic and social growth. Where agricultural growth has been neglected in favor of one-sided industrial expansion, growth of the whole economy has suffered. Fortunately, this is now widely recognized, at least in theory, by development agencies - even if some have tended to lag behind recently in assigning enough resources to their agricultural portfolios and particularly to help at the farm level.

Besides the four broad positive goals, development agencies have another ethical and practical responsibility: they must support no agricultural program, project, or policy that is now, or is likely to become, environmentally damaging. Fortunately, in many development agencies, procedures have been put in place to assess the potential environmental damage of such projects and programs, very correctly at the planning stage. But in almost every agency, sound environmental procedures need to be enforced with greater rigor during project implementation.

The Stubborn Problems of Increasing Agricultural Productivity

Leaving more specific recommendations momentarily aside, what are the most serious practical problems that farmers, governments, and development agencies face in trying to increase agricultural production sustainably?

We have made the general case that rapid deterioration of soil and water quality and, with it, deteriorating agricultural productivity may turn out to be the Achilles heel of efforts to achieve agricultural sustainability. Now the crucial details bear

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examination. Many of even the well-endowed lands suffer from serious degradation -- erosion and on irrigated lands salinization and waterlogging. But the problems of land degradation are even more troubling on the huge areas of less fertile land now farmed. Farmers who are forced to move from infertile and crowded areas but who have few options will continue to invade lands that they don't know intimately -- too often, easily damaged marginal lands, lands with steep slopes, forested lands, or very dry lands. Little high-quality arable land remains unoccupied, and as expansion proceeds onto ever less desirable land, productivity is likely to drop further. In such places, environmental degradation and growing poverty are too inextricably entwined with population pressures to be dealt with in isolation. Without linked successes in lowering population growth and in initiating better resource management, other measures designed to alleviate poverty will fail. Without also attacking the basic causes of poverty, better resource management alone will not suffice.

Efforts for enhancing sustainable productivity on the better lands must continue. They may well for the immediate future be able to produce enough food to support the demands of expanding urban populations for more and better food. But the importance of the less well-endowed lands must not be underestimated. As difficult as it is to wring more productivity from these lands, roughly half of the world's farm families live there and roughly half the developing countries' total food is produced on these same farms. Moreover, millions of additional farmers, even though they are no longer able to scratch out much of a living on their land, have no realistic prospect of finding meaningful livelihoods in the cities or on other lands. Ensuring the productivity of every bit of arable land is thus one of the greatest challenges faced by farmers, developing countries, and, consequently, by development agencies. We forget at our peril that it takes 500 years for one inch of soil to be formed and that six inches of soil are needed for agricultural production.

Several Principles that Must be Reflected in Programs for Sustainability and Food Security

Several basic principles underlie sustainability and should be reflected in development agencies' agricultural programs. Most agencies already generally recognize these principles, but they deserve reiteration.

A first principle is that the success of any country's efforts to achieve agricultural sustainability depends to a great extent on getting for the farmer more -- and more effective -- help and encouragement from development agencies, governments, and non-governmental organizations. Paradoxically, the farmer tends to be the most neglected person in today's agricultural development

paradigm, even though he (and, increasingly, she) is in the final analysis the principal engine for increased production. Farmers' decisions about whether and how to plant and nurture crops and whether to adapt suggested changes in production methods depend upon their views of the risks and labor involved.

Unfortunately, development agencies still tend to downgrade and overlook farmers -- particularly small farmers -- instead of helping them. Reasons vary: some developing countries tell these agencies that they have higher priorities or insist that work with farmers is solely their own responsibility and actually resist their efforts to work with farmers. Sometimes governments do take such positions. But the need to help farmers is so central to success that development agencies must tactfully insist on establishing effective channels for helping farmers.

Of course help to the farmer is not the only key to successful agricultural development. Far from it. Producing enough food and other agricultural products for export requires a flow of scientific technology, good farm-to-market infrastructure, and good government price and tax policies. But help to farmers is today the most neglected aspect. The typical method of too many development agencies has been de facto to downgrade help to the farmer by chiefly working through large sectoral loans to governments, with little control kept over how loans are spent. This too seldom results in programs that reach small farmers, let alone persuade them to adopt new technology.

Most sectoral loans also have their environmental drawbacks. Where loans and grants have been used to extend credit to farmers, they have seldom helped to protect the environment -- or to provide much credit to the poorer farmers for that matter. Government credit institutions in developing countries rarely assess projects that they finance for environmental soundness, let alone support the kind of technical assistance for farmers that will make their loans more credit-worthy. There are, of course, interesting exceptions.

Most large government-sponsored rural development projects financed by development agencies have been too complex, too oriented toward infrastructure construction, and too involved in higher-level institution building to give priority consideration to farmers' needs. Where sectoral loans without sensitive follow-up have been used to finance extension and research, they have -- with important exceptions -- too seldom resulted in the direct involvement of farmers because of the weaknesses and attitudes of research and extension services.

A second principle worth remembering is that farmers will not incorporate changes in the way they farm or increase their labor to achieve sustainability unless they are convinced of early returns and are certain that their survival systems will not be

jeopardized. Most development agencies acknowledge this principle in theory. But they often fail to put into practice another part of the formula, namely that a key to mobilizing farmer cooperation is designing and launching simple economic incentives for farmers, especially incentives for conservation.

Getting farmers to conserve their soil and water, while central, is often very difficult. Survival, for poor farmers, must come first. Farmers are no more moral or benevolent than others. Most farm families, when faced with the immediate problems of short-term survival and debt repayment or with prospects for quick profits, disregard natural resource conservation and protection. Only when they are shown a more profitable way and only when they are secure in the tenure of their lands will they change their approach. Thus, the poor -- often out of perceived lack of choice -- damage the resources on which their survival depends.[3]

A third principle for development agencies and governments is to avoid the complications of earlier overambitious and overly complicated "integrated rural development projects." Particularly at the start, projects that aim directly at help for a farmer must be as simple as possible and always within farmer's physical and financial reach. In most cases, projects should begin with the introduction of one or two solid elements (say, simple and effective erosion or water conservation measures) that farmers believe will meet their needs. Only after farmer income and farmer confidence increase should additional elements be added.

A fourth principle that governments and development agencies seeking sustainability and food security should consider is that while their efforts must include all farmers, special efforts are needed to raise the productivity of the poor majority of farmers, including the landless. These, and not the well-to-do farmers, are the people most in need of help and least likely to be helped. Further, evidence shows that raising the well-being of the large mass of rural poor -- and not just raising the income of more prosperous or more skillful farmers -- is the key to agricultural growth in developing countries.

A fifth principle which must guide the development agencies is that more -- and more practical ways -- to help women farmers must be designed and put into practice. In many areas, women grow most of the food. Unfortunately, there is a strong global trend toward the feminization of rural poverty. More efforts must be made to meet the specific needs of women farmers and their families -- for secure land tenure, for better access to credit, for appropriate extension, for education, for access to information on

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[3]Many well-to-do farmers and ranchers are equally or even more destructive of natural resources, even though they have the means to improve the quality of rural life for all.

family planning, and for technologies that will reduce the time needed to carry out their numerous responsibilities. In many places, real increases in productivity will be a chimera until women farmers are no longer discriminated against and instead are helped to position themselves to receive the rewards and dignity of their labor.

A sixth principle is that special attention must be given by the development agencies to finding better ways to disseminate information to farm groups about farmer-friendly methods to improve production and better manage natural resources. Development agencies' staffs must personally become effective change agents charged with helping the farmer, particularly the small farmer. Although they now too seldom come into direct contact with farmers, development agency staffs must attach high priority to efforts to reach out to them.

We recognize that putting these principles into practice will not be easy for development agencies. They must first convince often reluctant developing-country officials that this six-pronged approach is the best way to go. Politicians facing pressing problems of political survival -- often perceived as a matter of meeting the urgent problems of urban groups -- often resist according higher priority to help other than politically powerful large land holders. Too few governments in developing countries have taken the problems of the rural mass to heart or been willing to take the political risk of allowing, let alone encouraging, rural empowerment. Fortunately, there are important exceptions.

But if developing countries are going to be able to feed their people, they must somehow come to understand the urgency of active encouragement of rural production. Indeed in all probability, the large grain surpluses, until now often available free or on concessional terms from the United States and Canada, may one day no longer be available to make up for food deficits. Further, farmers in developing countries are likely to face the increased cost and even the availability of petroleum-based agricultural inputs (pesticides, chemical fertilizers, and fossil energy), although some new inputs based on natural gas hopefully will come available. It is a sin against humanity that so much natural gas which could be used for fertilizer is now flared. As petroleum-based inputs become more expensive and less available to the poorer farmers, alternative systems for nutrient supply and protection against pests will be absolutely essential.

A Basic Agricultural Agenda for Development Agencies

How should the development agencies proceed? Certainly, agricultural development programs will -- and should -- differ from one development agency to another. But all agencies must recognize

the increasing importance of working together and defining their agricultural roles in a common strategy designed to reverse the deterioration of global agriculture.

The basic tasks, as we see them, are:

(1) Making Better Plants and Cultivation Practices Available to Farmers

As already indicated, the overall highest priority for development agencies must be to develop and to bring farmers the most productive and most rugged plants and the best cultivation practices. Prime examples of both already exist and only await better means of dissemination. Yet, far more work on both better plants and low cost, farm-tested, labor-sensitive production systems is needed too.

Much of the prototype agricultural technology will come from the international agricultural research centers (IARCs) -- particularly, but not exclusively, from those within the Consultative Group for International Agricultural Research (CGIAR). But too much reliance must not be put on these Centers. Biological technology is too site-specific to allow the Centers to fulfill this latter role. A network of robust national research systems that will work closely with the international centers and other national centers must be the eventual goal. Fortunately, too, an increasing amount of very useful practical experience and insight is being gained from the work in agricultural development of local community-based organizations and private voluntary organizations. The development agencies must contribute to ensuring a constant flow of research results in every way they can.

Examples of the kinds of important technology that must be produced are:

a). techniques that conserve and improve soils;

b). technologies for integrated pest management[4];

c). improved plant materials that will increase productivity, reduce plant stress, augment fertility, reduce the need for pesticides and herbicides, produce higher farm income, and make effective use of biological resources;

d). improved cropping techniques;

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[4]A more detailed discussion of these technologies and systems is contained in Annex A of this paper.

e). techniques for improved irrigation and for low-cost supply and conservation of water;

f). technologies for the conservation of energy;

g). means of protecting forests, grasslands, wetlands, and coastal systems that must be used as common property by villages or which, if more distant, influence farm productivity; and

h). techniques that farmers can use to incorporate cattle, small ruminants, fish, and poultry into farming systems.

The concept of agricultural sustainability highlights the necessity of adapting plants and systems to the production requirements of the various ecological zones in which farmers work. In the strategy respected by most of the IARCs, the country-specific and region-specific adaptation process was to be carried out by the national agricultural research centers. Unfortunately, too few of these centers now have the capability to successfully adapt much technology, so other ways must be found. In some places, the IARCs may, through cooperation with international scientific and academic organizations, and through cooperation with the development agencies, be able to help more directly in the adaptation process.

Also, U.S. Land Grant Universities and other academic institutions in the industrial countries working on agriculture in developing countries have much unused potential to help in both research and local adaptation, working in closer collaboration with the IARCs and always in collaboration with local colleagues. The development agencies should take more initiative in helping to organize and finance such efforts. Community-based farm organizations and private voluntary organizations should also be enlisted to help, particularly with field trials.

The development agencies, in close cooperation with each other and with the other generators of agricultural technology mentioned here, must also take responsibility for better identifying and publicizing the existence, source, and potential of the best of these plants and systems. Building on good work done so far, better access to this information must be provided through specialized computer networks and wider access to these networks.

Here, however, a word of warning is due. If the IARCs are to be able to provide these additional services and the greater flow of better plants and systems, not only to farmers on the better lands, but also to farmers on the less well-endowed land, the centers must be given substantially greater support. Accordingly, the development agencies and the national governments which support

them should increase their support for the international agricultural research centers -- both those that are affiliated with the Consultative Group of International Agricultural Research and the best of the rest, including important regional research centers.

(2) Programs for Direct Help to the Farmer

Once better plants and systems aimed at greater productivity and better conservation are developed, field-tested, and publicized, the next and most difficult step is to persuade farmers to use them. Here development agencies have an absolutely vital role to play, a task to which most agencies should give a lot more attention than they now do.

Admittedly, this charge poses a dilemma: it is unlikely that development agencies could or should carry out enough technical agricultural development programs to directly influence very many farmers. But they must work diligently together to assure that some way or other effective help reaches down to the farmer, the key person in the radical agricultural transformation that must be made. Where possible, the agencies' best option will still be to work through governments, bringing those reluctant to give a high priority to helping poor or small-scale farmers to the point where they have the sustained will and capacity to give farmers effective help. Development agencies must particularly seek to convince those governments unwilling to help small farmers that they must change their attitudes and reverse their policies in their own self-interests.

In countries with weak research extension systems, both a long-term and a short-term approach to improving help to farmers is needed. In the long-term, development agencies will want to support the process of creating and strengthening genuinely responsive and culturally appropriate research, training, and extension capacities at the national and, occasionally, at the regional level, whatever the weaknesses of existing systems.

But in some countries, the immediate challenge is too grave to wait for official extension systems to become stronger and friendlier to farmers. In the short-term, the best, if imperfect, vehicle for reaching small farmers with new technologies may be through community-based and other non-governmental organizations. Where governments are friendly or neutral toward private organizations, working more through those governments to support community-based organizations may be the right way for development agencies to proceed. If governments are not friendly, the development agencies should, as already urged here, use their influence and whatever leverage they have to tactfully but firmly help turn around governmental attitudes toward these community-based organizations. In fact, strong NGOs and other rural organizations can often be important allies for the development

agencies in efforts to put political and social pressures on official agencies for better performance.

Also development agencies should go further: they should find new ways to make more grant assistance available to rural community-based organizations, including assistance through friendly and competent external non-governmental organizations. Some agencies must also simplify ways of working with non-governmental organizations and remove or relax cumbersome reporting requirements and procurement regulations.

Going still further, development agencies should cooperate with each other and with local authorities to create or strengthen competent rural community-based organizations or other appropriate non-governmental organizations. They should then help develop the channels for getting simple, inexpensive, time-sensitive technologies for production and conservation to these organizations and help them locate, train, and initially support the kind of sensitive change agents (most often local people) who work well with farmers and have access to and understanding of new plants and new management techniques.

The next logical and crucial step is for development agencies to find ways, working through governments where possible or in some ad hoc fashion where governments are weak or unfriendly, to help larger groups of farmers adapt successful new methods of farming to their own special circumstances by extending considerable financial and technical support. This is the difficult scaling-up process. In fact, there are already hundreds of successful models of scaling-up in the developing world -- many involving community-based organizations and farmers in almost every ecological and financial circumstances. Only when scaling-up is completed on a wide front in every developing country, and only when these efforts are sustainable, can this phase of agricultural development be considered successful.

(3) Programs for Agricultural, Natural Resource, and Environmental Training

While training has long been an important aspect of development agency agricultural programs, even greater effort to help governments create the local, national, and regional capacity to understand, analyze, and plan for meeting agricultural, environmental, and natural resource problems is warranted. Support for training capacity in these disciplines at all levels, including the lower technical levels, must continue to have high priority. Locally and regionally, private voluntary organizations and non-governmental organizations with development agency support could take on a larger share of this training. Every government has the responsibility to make the right kind of environmental and agricultural training and education available to its citizens. For smaller countries without the financial capacity needed to sustain

a whole array of agricultural and natural resource management schools and institutions, and for countries that share common agricultural and environmental problems, regional training and research institutions may be appropriate, and development agency support of regional institutions should be increased.

(4) Programs for Strengthening the Agricultural Economy Above the Farm Level

Although development agencies' search for better ways of helping the farmer is the bedrock of the recommendations put forth here, other agency-sponsored agricultural development programs are also important. Increased productivity will mean nothing to farmers if they cannot physically dispose of their production, and at a reasonable cost and if they cannot buy what they and their families want and need.

Just as important are governments' agricultural and rural policies, attitudes, and operations. Through the leverage provided by financial and developmental assistance and through their constant contacts at both the political and working levels, development agencies can have a real impact on these aspects of government thinking and action.

(a) Infrastructure Assistance

In many parts of the developing world, the lack of farm feeder roads (and the lack of the capacity and will to maintain them) as well as the lack of adequate food handling, transport, marketing, storage, and processing facilities are major barriers to the achievement of sustainable agricultural economies. Provision to governments of funds to construct (and, in some instances, to reconstruct and maintain) infrastructure has long been a major and appropriate focus of development agency financing. Except in the poorest countries, however, most infrastructure financing should be left to the increasingly accessible global capitol market. And even in the poorer countries, development agency financing of infrastructure should not be overstressed to the detriment of production assistance to farmers.

Rural infrastructure should be built in a way that is sensitive to and protective of the environment. The collapse of poorly constructed rural roads, for instance, has resulted in the destruction of too much good farmland.

Irrigation infrastructure is especially important. Special precautions in planning and implementing programs for irrigation construction, maintenance, and training should be continued. Even though land appropriate for new irrigation projects is becoming increasingly scarce, some countries could undoubtedly make good use of more -- and more effective --

irrigation systems, though costs will be increasingly high. The day of big dam building and big irrigation system building is largely over because most of the good sites have been exploited and because remaining sites are seen to pose unacceptable environmental risks or resettlement problems. But small, farmer-controlled systems are still appropriate targets for development-agency lending so long as stringent conditions are attached. Such guidelines are needed because statistics show that in too many countries more irrigated land is going out of production than is coming into production, principally because overuse of water results in salinization and waterlogging. Development agencies should finance irrigation projects only if proper drainage for saline waters (usually this means lined canals) is part of the package, if adequate and continuing training of farmers in water use is provided, if subsidies that encourage overuse of water are eliminated, and if irrigation rights are fair to the small farmer and "tail end" water users. Finally, much stricter and longer monitoring of all aspects of irrigation construction and use should be financed and supervised by the development agencies.

We should note here that irrigation is important in humid areas as well as in the arid areas. For example, irrigation systems -- often centuries old -- for paddy rice must be maintained. The differences between irrigation in humid and arid areas must be recognized.

(b) Encouragement to Adopt Wise Rural Policies

Deeper agricultural reform at the national level continues to be urgent in many developing countries. Development agency efforts to use their financial and intellectual leverage for the reform and rationalization of government structure, for the establishment of market prices that will encourage production, for the abolition of inefficient and market-distorting agricultural parastatals, for the elimination of water and pesticide subsidies and the rationalization of fertilizer subsidies, for the restructuring of agricultural credit (especially to make it available to small farmers and women), and for the encouragement of socially just and economically sound land tenure programs are very important. For the agencies with major financial resources, working through structural adjustment loans in cooperation with the International Monetary Fund makes sense. But structural adjustment in agriculture can be environmentally damaging if it encourages agricultural production that overtaxes the resource base, encourages overuse of water or chemical inputs, or destroys governments' ability to support essential and viable planning, research, extension, training, and monitoring institutions. Development agencies need not only to be most careful to avoid these

pitfalls, but to avoid concentrating resources on structural adjustment programs at the expense of programs to ensure better assistance to farmers.

(4) Programs that Deserve Special Attention

(a) Help in Establishing Cost-Effective Programs for Soil and Water Conservation and Watershed Protection

Nothing is more basic than conserving the soil, water, and biological resources on which agriculture depends. In practice, however, few things are more difficult. Unless farmers invest their time and labor willingly, soil and water conservation projects at the farm level are soon neglected. But to be willing to invest their time and labor, farmers must have secure tenure for their land and see prospects of early economic return. Soil and water conservation in major watersheds is particularly important and particularly difficult because the upper watershed farmer seldom receives benefits commensurate with those received by downstream beneficiaries (prevention of dam siltation, secure urban and agricultural water supply, flood control). Development agency support of soil and water conservation programs is of special importance because of the magnitude of the resources required, at times the need for international and interregional cooperation and coordination, and the disproportion of benefits. But since success depends on the skill and determination of many small farmers, motivating them is of the greatest importance. The cooperation of experienced community-based organizations is again a vital asset.

(b) Help in Rationalizing Agency and Developing-Country Policies on Chemical Fertilizer and Pesticide and Support Integrating Pest-Management Research and Use

One of the most controversial aspects of assistance to farmers is of the subsidization of chemical fertilizers and pesticides. Too often subsidies have led to overuse or misuse of these inputs. In many circumstances, overuse of pesticides has had disastrous health consequences for farm families and has also fostered the build-up of pest resistance to the point where available pesticides no longer work. Also, particularly in the case of fruits and vegetables for export, the build-up of dangerous pesticide residues will increasingly lead to importers' rejection of shipments. Given these alarming trends, the development agencies that have not already done so should not only establish and implement strict controls on their provision of pesticides and on pesticide use in developing countries. They should also always provide rigorous training for pesticide users.

Development agencies should give a much higher priority to support for the development and use of farmer-friendly, more easily applicable integrated pest management methods, and urge the national and international agricultural research centers to do the same.

As for chemical fertilizers, in many situations their use is necessary for increased farm productivity. But overuse of chemical fertilizers is in too many places polluting water sources and, in some, degrading soil quality. Consequently, major development agency objectives must be: to foster more efficient and cost-effective use of chemical fertilizers where they are available, needed, and within the financial reach of farmers; to convince governments to rationalize fertilizer subsidies; and to promote even greater development and use of local mineral sources and biological sources of farm nutrients, particularly for farmers without long-term access to chemical fertilizers.

(c) Support for Programs that will Ensure Farmers More Secure Land Tenure

One more difficult and politically sensitive challenge in many countries for the development agencies is to improve the prospects for secure land tenure for small farmers. The many difficulties and limitations of land reform programs aside, farmers cannot be expected to expend the physical and financial resources needed to conserve soil, water, and plant cover until they have sure tenure of the lands they cultivate. Development agencies must take stronger (if quiet) initiative to encourage broader programs for secure land tenure.

(d) Support for Aero-Forestry Schemes and Better Land Use Planning When Forested Areas Must Be Settled

Given the urgency of protecting the biomass and the biodiversity represented by tropical forests, development agencies are now recognizing that extreme caution must be taken in financing agricultural development or settlement schemes in or near forested areas. Forested lands with volcanic or alluvial soils strong enough to support careful continuous cropping are likely to be opened to farming, barring the most aggressive and successful efforts to the contrary. Similarly, under strong population pressure, even forested areas with poorer soils will almost inevitably be cut for farming. In forested areas already occupied and in nearby second-growth areas, which if properly farmed could take the pressure off the uncut forests, major efforts should be made by development agencies to encourage the use -- by small farmers particularly -- of tested agro-forestry technologies. This often means the introduction of tree crops as a source of cash income. There are admittedly problems of

over-supply of some tropical tree crops, but the environmental and commercial advantages of growing existing tropical crops (rubber, palm oil, tea, coffee, cacao, etc.) and possible new crops are so great that every possibility for their expansion and sale should be explored carefully.

Nonetheless, the development agencies, in approaching requests for loans for development in or near forested areas, should follow certain principles: base all decisions on careful land-suitability studies; do not loan money for the exploitation of areas of unique biological diversity and insist that developing countries not use their funds for this purpose; do not finance highway construction near or through forested areas; respect the rights of indigenous peoples; and, because of the potential of global warming, help and encourage developing countries to avoid the net loss of tree and plant material by providing for compensatory tree planting.

The Crucial Importance of Family Planning Programs

Longer-run efforts to bolster agricultural productivity and to better manage natural resources will fail unless today's explosive population increases can be brought under control. The world cannot wait for better education and living standards to have a dampening effect on fertility levels before taking much more determined efforts to bring the population explosion under control. Even the most successful efforts at achieving agricultural sustainability will ultimately falter under the pressure of impossibly high population levels. For this reason, the development agencies need to be much more aggressive in supporting family planning. However sensitive the correct choice of methods to achieve this objective, so much remains to be done in so many countries that development agencies can and must find an honorable way to push governments forward.

Conclusion

The recommendations put forth here are admittedly ambitious, difficult, and in some respects novel. Carrying out such an agenda will require considerably more cooperation among development agencies, the dedication of new resources in people and money to those tasks, and in most cases an increase in agriculture's share of development agencies' budgets. Focusing more help on small farmers will inevitably take a lot of time and money. And shifting more attention to the farm level may in some cases require agencies to rethink their missions and even reorganize operations. For the principal development agencies are not yet organized in a way that will enable them to help farmers increase productivity on a large-

enough scale on a long-term basis to turn the tide. This is a very basic problem that requires a lot more attention by development agencies and those who give them financial and political support. The same kind of rethinking must be given to how agencies finance agricultural development. Given developing country debt, a number of agencies, particularly the largest, must find ways to increase grant assistance.

All that we've said here adds up to one basic premise: there's an urgent and primary need for development agencies to focus more thought and resources on helping developing countries achieve agricultural sustainability and increase food production to a level high enough to feed rapidly growing developing country populations. Support for such programs is equalled in importance only by the need for support for population programs and, in another area, protection of the earth's climate. The time for agencies to make a many times greater commitment to these objectives is now, for even the right decisions can't bear fruit overnight. Meanwhile, the timebombs of rapid population growth and natural resource degradation are ticking relentlessly away.

ANNEX 1: THE CONCEPT OF AGRICULTURAL SUSTAINABILITY

The Committee considers sustainability in agriculture to be a dynamic concept, defined as the ability of an agricultural system to meet evolving human needs without destroying and where possible improving the natural resource base on which meeting these needs depends.

While there are numerous more and less complicated views on agricultural sustainability, the Committee has not worried too much about a strict definition at this broad conceptual level or about the small differences between the above definition and many other useful explanations. The Committee recognizes other definitions as valid if they emphasize a few central factors: the dynamic nature of sustainable agricultural systems (what is sustainable in one time and place may not be sustainable at a later time or in other circumstances); the need for agricultural interventions to meet the evolving needs of the farmer and provide early returns for their efforts; and the need to protect the farmer's natural resource base of water, soil, vegetative cover, and fauna. The Committee views sustainability as fundamental to the long term economic and ecological health of farms and farming systems in the developing countries.

The broad conceptual definition of agricultural sustainability, such as the one above, is useful for at least two purposes: it provides a framework for multi-faceted, multi-disciplinary and thus more rigorous examination of agricultural development. And just as important, a broad understanding can provide powerful answers to difficult political questions of whether investment in development will have a worthwhile long term impact, as compared to similar investment in other needed domestic or foreign programs.

However, in the last two years, the Committee's attention has evolved to put greater emphasis on a farm-level, operational definition of agricultural sustainability: agricultural projects and programs, to be sustainable, must be site-specifically analyzed to provide for the different physical and social conditions under which they must operate.

It is true that the Committee tends to pay special attention to the environmental, ecological and biological requirements for achieving sustainability, and especially to the necessity for proper management of soil, water, and vegetative cover. But the Committee also recognizes the need for all agricultural development to be based on the aspirations and limitations of farmers and on their own perceptions of opportunity and risk.

If the Committee focuses closely on these dimensions, however, it is because they have long been neglected in the development process and not because they are the only important aspects of

agricultural sustainability. Indeed there are other equally important agronomic, economic, institutional and political aspects of sustainability, but it is not fruitful here to debate the relative importance of these various facets. They all must be served and come together in a systematic way.

The Committee also recognizes that while there are very important dimensions of sustainability which apply directly to the farmer, the farm family, and farmers' organizations, there are others which apply to the off-farm world of trade and politics. Taking full account of farmers' desires and limitations must be the solid foundation on which agricultural development and research are built. However, farmers' capabilities -- even those of well-organized farmers -- extend just so far, and development agencies must pay attention to government policies and practices. The art lies in choosing which factors in any given situation are the most important and/or the most amenable to change for the better, due recognition being given to the comparative advantage of different development agencies and other outside organizations which are ready to enter into cooperative efforts.

ANNEX 2: PRINCIPLES OF SUSTAINABILITY FOR AGRICULTURAL AND RURAL DEVELOPMENT PROJECTS

Even with a focus on environmental issues, principles of sustainable agricultural production cannot be considered in isolation of many other concerns. The following sets of principles attempt to recognize many of these other issues which should also be incorporated into agencies' agricultural and rural development programs.

I. Environmental and Ecological Principles

Generally, sustainable agricultural and rural development systems should:

1). Minimize erosion and maintain and improve soil utilization, fertility, structure, and productivity.

2). Be designed to achieve the greatest efficiency in utilization and conservation of basic farm and natural resources (soil, water, sunlight, energy, planting material, and farmers' capital and time).

3). Integrate as much biological interaction as possible such as: mulching, nitrogen fixing plants, agroforestry, inter-cropping and crop rotations, contour and alley farming, and biological control of pests.

4). Minimize and help phase out the use of health endangering, expensive and/or environmentally damaging off-farm inputs[5] and, in their place encourage the efficient use of on-farm inputs such as animal manures, green manures; and greater reliance on the natural enemies of pests. Of particular concern are pesticides (insecticides, fungicides, and herbicides) that destroy non-target organisms and that are environmentally mobile

[5]In many situations some use of external inputs is necessary and justifiable, but the Committee is concerned about the development of unsustainable dependence on off-farm inputs -- largely due to the likelihood of rising costs of petroleum and petroleum-based products (such as some fertilizers and pesticides), declining returns, and environmental impacts (contamination of water tables, development of weed and pest resistance, loss of soil quality, etc.). The Committee urges maximizing the use of available, affordable, renewable and environmentally benign inputs and supports giving the highest research and development priority to the progressive attainment of the goal of minimizing off-farm inputs.

or toxic to humans and animals, and should be replaced whenever possible by cheaper weed control techniques and by adopting pest-resistent crop varieties.

5). Avoid the overuse and contamination of surface and groundwater, and which strive toward efficient use of water in irrigation.

6). Preserve as wide a genetic base as possible in crops and animals and the widest possible species diversity on the farm and in surrounding natural areas. This involves movement away from monocropping and dependence on single product and species cultivation as well as minimization of forest clearing.

7). Encourage diversified and mixed farming systems that incorporate and manage both crops and animals (cattle, small ruminants, chickens, rabbits, fish, and other animals) to provide food, fertilizer, and farm energy. Such systems especially require the controlled grazing of cattle in watersheds, and introduction of stall feeding despite the resulting labor demands for gathering forage as well as better on-farm management of animal manure to minimize unnecessary methane generation.

II. Economic and Social Principles of Sustainable Development

Economically and socially sustainable agricultural systems should generally:

1). Be profitable and meet the needs of farm families, for cash income, producing goods suitable for local markets and providing fuller employment opportunities for farm families, providing stability for farm communities, and providing for special recognition of, and help for, farm women. These systems can take advantage of new crop varieties that respond to lower nutrient inputs.

2). Meet the energy needs of farm families to work their land, cook, and heat. Such energy must have a readily available, affordable, and whenever possible renewable source. The Committee emphasizes the need in rural areas to plant more biomass for combined urban-rural use.

3). Protect the rights of indigenous groups by promoting community participation and reflect indigenous social

systems, particularly with regard the role of women in farming.

4). Allow farmers to acquire title to their land and that respect access to badly needed common property (communal woods, ponds, irrigation systems, grazing areas); or, where communal property is customary, that give farmers an adequate sense of tenurial security.

5). Enable effective local management of community-controlled common property resources (ponds, woodlots, grazing lands, irrigation systems) in ways that permit equitable community control, sharing of benefits, and marketing outlets, even as society evolves and communities change.

6). Reduce farmer financial risk and be flexible enough to enable/encourage farmers' rural survival through difficult times (famine, drought, and natural or political disasters). For example, such a system would work to minimize the use of expensive fossil-based chemical fertilizer.

III. National and International Policy Considerations of Sustainable Development

The Committee does not mean in any way to neglect or exclude from its concept of sustainability other important national and international parameters. It recognizes that many off-farm factors are crucial, in the long run and often even in the short run, to farmer prosperity and to farming sustainability. Some of these are:

1). The willingness of research organizations, economic development agencies, banks, and developing country governments and institutions to accommodate the continuing evolution of sustainability concepts and practices. This requires a long term commitment to their achievement.

2). The growing need to persuade developing country governments to change their policies and programs in order to provide incentives for the adoption of sustainable agricultural systems. Governments must reconsider discriminatory tax policies, agricultural subsidies and price controls, land holding policies and practices, food pricing policies, and transport policies -- any aspect of government policy that puts farmers, particularly poor farmers, at a disadvantage. Farmers and the farm sector must not only receive their

fair share of natural wealth and attention, but also strong incentives for conservation.

3). Equitable access to rural economic infrastructure, to credit and to necessary inputs. These must be available to the poor farmers - especially women farmers - as well as more prosperous farmers on a continuing, fair, nondiscriminatory basis.

4). Fair access to social infrastructure -- schools, facilities for health care, family planning, nutritional advice, etc.

5). Fair access to national and international markets where farmers can get a price for their produce that will cover their costs and give a fair return, such as development of local market structures and cooperative ventures.

ANNEX 3: ELEMENTS FOR SUSTAINABILITY TO BE INCLUDED IN AGRICULTURAL DEVELOPMENT PROGRAMS

TECHNIQUES WHICH CONSERVE AND IMPROVE SOILS AND CONSERVE WATER

In the Committee's view, not enough has been done to introduce simple, cheap soil and water conservation techniques into agricultural projects. Heavy emphasis should be put upon soil and water management and related agronomic and cultural practices. These could, where appropriate, include:

-- Protection against water erosion: planting ground cover; tree planting along terraces; building contour terraces; bunds on steep areas; check dams; infiltration ditches; terrace construction; gully plugs; low dams; stone and trash lines; conservation tillage; and alley cropping.

-- Conservation of water supply through forest conservation and reforestation.

-- Protection against wind erosion: dune stabilization by palisade construction and tree planting; planting trees for windbreaks; planting of ground cover; and planting of narrow grass hedges (vetiver grass, etc.).

-- Restoration and maintenance of soil fertility: use of mulching; crop residues; animal and "green" manure; dispersed farm tree planting and other agroforestry practices; methods to increase organic content of soil, particularly in arid and semi-arid zones; use of farm wastes and "pure" sludge as soil amendments; and the use, where appropriate and possible, of cheap, locally provided, efficient mineral fertilizers, particularly as sources of phosphorus and minor elements.

-- Restoration of abandoned lands, as difficult and expensive as this may be.

Almost all soil preservation and restoration projects involve substantial investment of money and time. Some are relatively cheap (trash lines) and some expensive (terracing). Outside financing of expensive techniques is very often necessary. However, this should not be undertaken unless farmers are genuinely convinced that such projects are in their vital interest. Farmers must be willing to invest their own time and even some funds in the construction and maintenance of soil conservation structure.

WATER MANAGEMENT: (1) Low cost techniques for better supply and conservation of water and for improved and locally controlled water management at the village level; (2) better management of modern irrigation systems.

-- Construction or improvement of small scale irrigation systems including traditional irrigation systems.

-- Formation and management of irrigation users associations.

-- Training for irrigation technicians and farmers in better operation of irrigation systems and in the use of methods which prevent salinization, waterlogging, and, where possible, water-borne diseases. Development agencies should not finance irrigation projects where training and monitoring are not provided for.

-- Technical and organizational help in establishing mechanisms for watershed management and runoff control on or above village lands.

-- Dry land techniques for water conservation: field grid systems, water spreading, water channelling, and water harvesting (infiltration) systems, etc. In many areas there is great potential for significant returns from water conservation at a low cost, and this work should have higher priority.

IMPROVED PLANT MATERIAL:

Efforts must be reinforced, among other things, to produce through research and development plants better able (a) to increase productivity; (b) to reduce plant stress, particularly in difficult environments (low rainfall, steep slopes, poor soils, etc.); (c) to augment soil fertility; (d) to reduce the need for outside inputs for pest and weed control; and (e) to produce higher incomes or otherwise improve the quality of rural life (better nutrition, sources of cash income to purchase essential external inputs, basic goods not produced on the farm, and amenities). Farmers should be encouraged to only grow crops for which local, regional, and world pricing prospects are good and particularly to avoid planting crops which are already in surplus production, a common error of some development agencies.

IMPROVED CROPPING TECHNIQUES:

-- Techniques that enhance productivity through better crop spacing, better timing of planting, intercropping, crop rotation, and use of biologically interacting plants for weed control.

-- Low tillage which will conserve soil and water.

-- Techniques for relay cropping, polycultures, crop rotation.

-- Agroforestry combinations, including forest and home gardens, both for the difficult arid areas and for moist tropical forest situations, in both of which on-farm production can also provide wood, forage, fruits, medicines, and other products.

PESTICIDE MANAGEMENT AND INTEGRATED PEST MANAGEMENT TECHNIQUES:

Integrated pest management (IPM) techniques already exist for some crops and may be capable of being introduced into new areas with minimal local adaptation. Given the rapid spread of resistance by major pests to pesticides and given the potential for harm from the misuse and overuse of chemical pesticides (water table pollution, food contamination, rejection of pesticide-contaminated food exports, farm worker sickness from exposure to pesticides), every effort should be made to develop, utilize, adapt, and extend farmer-friendly IPM and to give it a high priority in research programs. Implementation of IPM research has been too slow and, in the Committee's view, underfunded.

The development agencies have good pesticide regulations but sometimes are not careful enough about their implementation. Programs in this area should include:

-- Policy dialogue with host country governments to reduce economic and regulatory disincentives to IPM and promote improved pesticide legislation and implementation of regulatory policies regarding the import, production, distribution, handling, safe use, storage, and disposal of pesticides.

-- Development of IPM techniques within an inter-disciplinary and agro-ecosystem perspective.

-- A greater emphasis on exploring opportunities for the biological control of pests.

-- Cooperative programs to help farmers learn to identify insect pests and beneficial species, calculate economic thresholds, handle and apply pesticide safely, and minimize their use.

-- Cooperative programs with other development agencies to regulate the provision of pesticides for development programs that are potentially hazardous to humans and/or the environment; and to insure that IPM programs are

developed in cases where it is determined that pesticides will be needed.

ENERGY: Project components and techniques which meet needs for energy at the farm or village level, preferably from renewable energy sources for reduction of the burden of farm work; and for heating, through mechanization; renewable energy for heating, cooking, and pumping.

The Committee notes growing concern about the contribution of the use of wood biogas to global warming unless more trees are planted than are harvested. It urges early development agency-supported research on how rural families can contribute to the avoidance of global warming through more intensive planting of trees and bushes. For the immediate future, most people in the developing world have little choice but to use wood and manure. Also, in the not too distant future, alternatives may have to be found for those farm energy needs now provided for by most fossil fuels. It's not too early for development agencies to start building considerations dictated by both these problems into their programs.

-- Introduction of draft animals (absence of good, cheap or readily available animal fodder is often the chief constraint).

-- Home and village tree planting for fuel wood, particularly if combined with watershed preservation, provided broader objectives for countering global warming are observed.

-- Introduction of biogas digesters (which also supply a nutrient rich slurry), bicycle power, etc.

-- More efficient use of biomass fuels through better stoves, improved techniques for the production of charcoal, etc.

-- Solar energy for crop drying and preservation, etc.

FORESTS, WETLANDS, COASTAL SYSTEMS, AND GRASSLANDS: Techniques that provide for the protection of biological diversity in the sustainable use and protection of village-exploited forests, aquatic systems, and grasslands, as well as more distant forests, aquatic systems, and grasslands which impact the sustainability of farms.

-- Improved management of natural forests with a view towards sustainable regeneration, and equitable distribution of forest benefits.

-- Improved management of wetlands and coastal systems as a natural means of water purification, sediment control, and wildlife management.

-- Development of environmentally sound aquaculture projects and local fisheries, particularly as a supplemental source of farm income and better nutrition.

-- Rangeland rehabilitation and better communal management of range lands (development agencies should continue some practical experimentation to find more sustainable range management systems, despite some failures to date). Programs should emphasize the establishment of policies and improved management systems that match existing soil, vegetation, and water resources to fit in with the cultural practices of the herdsmen concerned.

RURAL INFRASTRUCTURE: Techniques which make possible more efficient and equitable village-level support of agricultural production, storage, processing, and commercialization.

-- Design and construction of farm or village level crop storage areas which cut unacceptable losses to insects, vermin and mould and permit marketing at a time of higher prices.

-- More efficient and locally controlled marketing systems relying on up-to-date marketing information, bulk storage, and adequate and timely transportation.

-- Local solutions to help meet the need for more cash at the time of purchase of seeds and other inputs, in part through the establishment of a credit system fair to producers, input supply and marketing cooperatives, food processing small enterprises, etc.

-- Locally controlled and equitable credit systems with easily accessible and low interest credit guaranteed by groups as much for women farmers as for men farmers. Too many top-down farm credit systems have proven to be unsustainable because of high cost, difficulty of financial control and repayment, and unwelcome intervention of governments and politicians. On the other hand, subsidized credit to prosperous farmers can result in the overuse of pumped water, fertilizers and pesticides.

-- Locally controlled means of purchasing and reselling needed farm inputs.

-- Locally influenced public extension system aware of farmer conditions and responsive to his needs on his terms.